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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXIII.—No. 2928.] *LONDON: FRIDAY, FEBRUARY* 10, 1922. [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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9087
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CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See advertisement pages 27 and 77.
PATENT WATER-TUBE BOILERS, AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND.
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HYDRAULIC and HAND,
of all types and sizes.
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Thos. Piggott & Co., Limited,
BIRMINGHAM 7411
See Advertisement last week, page 91.

S. Sokal, CHARTERED PATENT AGENT.
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T.N. 4515 Museum. 9675

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 9044

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 17. 9047

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For Paraffin and Crude Oil.
Sizes 1½ B.HP. and upwards.
Petters Limited, Yeovil.
Sizes 25 to 500 B.HP.
Vickers-Petters, Ltd., Ipswich
See advertisement alternate weeks. 9335

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BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works,
Manchester. Od 9733

Electric Cranes.
9862
S. H. HEYWOOD & CO., LTD., REDDISH.

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SPECIALISTS
in the
SALE AND VALUATION
of 1834
PLANT AND MACHINERY
and
ENGINEERING WORKS.
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Iron and Steel
Tubes and Fittings.
Sole Licencees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 8746
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See Advertisement page 77, Feb. 3.

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS, GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia. 9563
SHIPBUILDERS, SHIP REPAIRERS AND ENGINEERS.

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Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
Spur Wheels cut up to 9 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches or Barges
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

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Address, BURNETT AVENUE, HULL.
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OIL FUEL APPLIANCES,
Systems
PRESSURE, AIR, STEAM
For Boilers of all types.
KERMODES LIMITED,
35, The Temple, Dale Street, Liverpool.
Naval Outfits a Speciality,
also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
Supplied to the British and other Governments.
Telephone No.: Central 2832.
Telegrams: "Warmth." 4078

Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od 2487
See their Illus. Advertisement, page 97, last week.
RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

R. Y. Pickering & Co., Ltd.,
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
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London Office: Od 8353
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Henry Butcher & Co.,
AUCTIONEERS, VALUERS AND SURVEYORS
for
ENGINEERING AND ALLIED TRADES
and
INDUSTRIAL PROPERTIES. 9856
63 and 64, CHANCERY LANE, LONDON, W.C.2.

Electric Transporters.
S. H. HEYWOOD & CO., LTD., 9862
REDDISH.

John H. Wilson & Co., Ltd.,
Birkenhead.
See Illustrated Advertisement Page 100, Jan. 28, 1921.

Locomotive Shunting Cranes

Steam and Electric Cranes
EXCAVATORS, CRANE-NAVVIES, GRABS, CONCRETE-MIXERS,
SHIPS' WINDLASSES, WINCHES, and DECK MACHINERY. 9364
LISTS OF STANDARD SIZES ON APPLICATION.
London Office: 15, VICTORIA STREET, S.W.1.

John Bellamy, Limited,
MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes and Fittings.

Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 90. 9953

Economy!
HIGH BOILER EFFICIENCIES
ARE OBTAINED BY INSTALLING
Todd Oil Burners
FUEL OIL BURNING SYSTEMS,
HEATERS, STRAINERS.
49-51, EASTCHEAP, LONDON, E.C. 3.
TODD SHIPYARDS CORPORATION,
Builders of Steam and Motor Ships, Repairers, Electric Drive Installations.
Twenty-one Floating Docks, Two Graving Docks, Twelve Shipways.
25, Broadway, New York, U.S.A. 9960

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 540

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS.
Forgings. Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD.. 9310
E. GREENWICH, LONDON, S.E. 10 (& at Birmingham)

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice Making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c. &c. 9804

Electric Lifts
(UP TO 25 TONS.)
9862
S. H. HEYWOOD & CO., LTD.
REDDISH.

For Sale, One Dean, Smith and Grace LATHE, sliding, surfacing and screw-cutting 12 in. centres, 36 ft. overall, admits between centres, 10 ft. 4 in., with faceplate, saddle, compound tool rest, tail stock, independent chuck. This is a magnificent Lathe and is practically unused. £360.
One 3-ton ELECTRIC DERRICK CRANE, with steel mast and with steel lattice jib 60 ft. long, complete, excluding motor. This crane has all the usual derrick crane motions. £330. T 315
JOHN McSKIMMING, 45, Hope Street, Glasgow.

The National Foremen's
ASSOCIATION OF THE ENGINEERING AND ALLIED TRADES.
(Registered under the Trade Union Act.)
An Association specially formed to look after the interests of Foremen on their Supervisory Capacity. P 601
All communications to— H. W. REID, General Secretary. Head Offices— 95, Belgrave Road, Victoria, London, S.W.1.

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS. AIR HEATERS, STEAM AND GAS KETTLES, Merrill's Patent TWIN STRAINERS for Pump Suctions. } ROWS PATENTS.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

Yarrow Patent Water-tube Boilers.
9864
Messrs. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 9518
See Full Page Advt., page 64, Feb. 3.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

Diesel Engines, Six Cylinder,
two and four stroke, 550, 1000, 1300 HP. Excellent condition. Dynamos for above 250 or 500 Volts, D.C. Immediate delivery and low price.
Also 2-500 K.w. PARSONS TURBINE SETS, 250 or 500 Volts D.C., with Condenser and spare armature.
ELECTRICALLY DRIVEN AIR COMPRESSORS, 250 Volts D.C. Pressures 1500 to 3000 lbs. per square inch.
JENNINGS,
West Wall, Newcastle-on-Tyne. 9742

Taylor & Challen Presses
8195
About 200 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices.
TAYLOR & CHALLEN, LTD., Engineers, Constitution Hill, BIRMINGHAM.
See Full page Advertisement page 62, Feb. 3.

FOR
Drop Forgings
write
GARTSHERRIE ENGINEERING & FORGE CO., 50, Wellington Street, Glasgow. 9674

"Spencer-Hopwood" Patent WATER TUBE **Boilers.** *See page 88.* 9293
Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

GRAPHITED OIL. **"OILDAG"** (Reg.) BRAND.
GRAPHITED WATER. **"AQUADAG"** (Reg.) BRAND.
GRAPHITED GREASE. **"GREDAG"**
9508
E. G. Acheson Ltd.,
Dept. E., (Sole Manufacturers.) 40, Wood St., S.W. 1. Works: PLYMOUTH.

Locomotive Traversers
(ELECTRIC).
9869
S. H. HEYWOOD & CO., LTD.,
REDDISH.

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION,
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices; 129, Trongate, GLASGOW. Od 3547
Registered Offices: Clutha House, 10, Princes St., Westminster, London, S.W.1.

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
9731
See half-page Advertisement page 74, Jan. 20.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMMYER, M.I.C.E.
Founded 1854 by SIR WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 9310

University of Liverpool.

FACULTY OF ENGINEERING.
Dean:—Professor T. B. ABELL, O.B.E., M.Eng., R.C.N.C. Ret., M.Inst. N.A.
Prospectus containing full particulars of the following may be obtained on application to the REGISTRAR:—Engineering, Electrical Engineering, Civil Engineering, Naval Architecture, Metallurgy, Geology, Marine Engineering, Design and Drawing, Refrigeration, Mathematics, Physics, Chemistry. T 358

Engineering.—Technical Instruction.

GRAHAM M. STEVENSON, M.I.E.E. and M.I.Mech.E., Queen's College, Paradise Street, Birmingham. Individual tuition in Machine Design, Calculations of Electrical Power Transmission, Steam and Hydraulic Plants. Important positions are now held by pupils trained in Engineering by Mr. Stevenson. Interview by Appointment only. T 322

Correspondence Courses for

B.Sc., Inst. C.E., I. Mech. E., all ENGINEERING EXAMS. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to MR. TREVOR W. PHILLIPS, B.Sc. (Hons.). Assoc.M.Inst.C.E., M.R.S.I., etc., 8-10, Trafford Chambers, 58, South John Street, Liverpool. 9296

Inst. C.E., I. Mech. E., B.Sc.,

and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., M.I.E., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 566

Inst. C.E. Exams.—Successes

as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 25 years' professional experience. Address, 7434, Offices of ENGINEERING.

TENDERS.

BIDEFORD URBAN DISTRICT COUNCIL.

WATERWORKS EXTENSION 1921.

The Bideford Urban District Council are prepared to receive

Tenders for :—

The MANUFACTURE, DELIVERY, ERECTION, TESTING and MAINTENANCE of TWO SUCTION GAS ENGINES driving TWO PLUNGER PUMPS each capable of delivering 14,000 gallons of water per hour against a total head of 300 feet.

Copies of the Specification and Tender, etc., can be obtained from the Engineers, Messrs. ST. GEORGE-MOORE and LATROBE-BATEMAN, M.M. Inst.C.E., 91, Victoria Street, S.W. 1 on payment of a deposit of £1, which will be returned on receipt of a *bona fide* Tender.

Tenders in sealed covers, endorsed "Tender for Pumping Machinery", to be delivered at this Office by Mid-day, 7th March, 1922.

The Council do not bind themselves to accept the lowest or any Tender.

W. B. SELDON,
Town Clerk.

Town Clerk's Office, Bideford.
February, 1922. T 377

TO FIRMS WANTING WORK.

Quotations are Required,

either separately or collectively, for the following UNITS, which comprise new patterns of the Harley Heat Retaining System:—

A.—225, 3 in. bore Hand-operated Single-acting Brass Air Pumps; B.—75, 3 in. bore Double-acting ditto, but with different lines and layout; C.—300 double walled Brass Vacuum Tanks, circular section in two sizes, 7½ in. dia. by 43½ in. and 7½ in. by 61½ in., of thin gauge brass tube or rolled sheet; D.—300 Sets Small Control Valves and allied mechanism, to three designs embodying similar main details, in brass, &c.

The above are repetition products, subject to repeat orders, therefore applications from serious people are required.

Drawings, which show all details and may not be departed from, are obtainable from the undersigned upon payment of the following fees, which are not returnable under any circumstances:—For A and B separately £1 1s. each, together £1 10s.; C, 15/-; D, £1 1s.

The advertiser does not bind himself to accept the lowest or any quotation. Application to H. GEORGE HARLEY, General and Consulting Engineer and Proprietor of Harley Patents, Grand Avenue, Camberley. T 348

BUSINESS FOR SALE.

MACHINE TOOLS.

For Sale by Private Tender

as a Going Concern, by order of the Receiver for the Debenture Holders.

The BUSINESS and WHOLE UNDERTAKING of HARRY F. ATKINS, Limited, in Liquidation, Machine Tools Manufacturers, Old Fletton, Peterborough.

Comprising:—

The FREEHOLD ENGINEERING WORKS, with the Fixed and Loose Plant and Machinery, Fixtures, Fittings and Office Furniture, Tools, Jigs, Templates, Stores, Stock-in-Trade, Goodwill, Patent Rights, Patterns and Drawings.

Tenders will be received up to 28th February, 1922, when they will be considered. The Receiver does not bind himself to accept the highest or any Tender. Particulars and orders to view may be obtained from Messrs. DARKE, ROBSON & BATTY, 146, Bishopsgate, London, E.C. 2. T 337

PRIZE COURT SALE.

IN PRIZE (CLOSING SALES).
By ORDER and for ACCOUNT of the MARSHAL of the ADMIRALTY and PRIZE COURT.

To be Sold by Public Tender,

20 cases COPPER TUBES 4¾ tons gross, ex NOORDAM (per IMPORT) and WESTERDIJK (per IMPORT) lying in Warehouse, London Docks.
1 case COPPER TUBES about 7 cwt. ex NIEUW AMSTERDAM (per KITTIWAKE) lying in Warehouse, Liverpool.
ALL IN NEW CONDITION.

Tenders, in envelopes marked TENDER FOR COPPER TUBES and addressed to THE ADMIRALTY MARSHAL, Royal Courts of Justice, London, W.C. 2, must be received not later than Noon on THURSDAY, 16th FEBRUARY, 1922.

All Further Particulars may be had on application to the Selling Brokers, JAMES AND SHAKSPEARE, LTD., 1, Metal Exchange Buildings, London, E.C. 3. T 370

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of :—

1. HARDWARE.
2. OILS AND COLOURS.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.

Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Hardware," or as the case may be, must be left with the undersigned not later than Two p.m. on Wednesday, the 22nd February, 1922.

The Directors do not bind themselves to accept the lowest or any tender.

A charge, which will not be returned, will be made of £1 for each copy of Specification No. 1, and 10/- for each copy of Specification No. 2.

Copies of the Drawings may be obtained at the Office of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.

W. B. REYNOLDS,
for Managing Director.

91, Petty France, S.W. 1.
2nd February, 1922. T 388

BY DIRECTION OF THE DISPOSAL BOARD.

SALE OF ENGINE ROOM PLANT AT THE HEAD POST OFFICE, LIVERPOOL.

Tenders are Invited for

the PURCHASE and REMOVAL from the Head Post Office, Liverpool, of certain PLANT which is in efficient running order, but is no longer required. Specifications containing full particulars and forms of Tender may be obtained on application to the Controller, Post Office Stores Department, Accounts Section, Studd Street Depot, London, N. 1.

Tenders will be received up to Ten a.m. on Tuesday, 21st February, 1922.

By Order of the
POSTMASTER-GENERAL.

General Post Office,
February, 1922. T 389

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders for the Supply

of :—
(1) PLATES, Mild Steel.
(2) BEATERS, Steel, plate layers'.
(3) CLOTH, Tracing.
(4) WHEELS and AXLES.
(5) DECK SPANS.

Forms of Tender may be obtained from the Director-General, India Store Department, Belvedere Road, Lambeth, S.E. 1, and Tenders are to be delivered at that Office not later than TWO o'clock p.m. on Tuesday, the 28th February, 1922, for Nos. 1, 2 and 3, and on Tuesday, the 7th March, 1922, for Nos. 4 and 5.

T. RYAN, T 397
Director-General.

THE ASSAM-BENGAL RAILWAY COMPANY, LIMITED, is prepared to receive

Tenders for :—

700 STEEL TYRES FOR CARRIAGES AND WAGONS.

Specifications and Tender forms may be obtained at the offices of the Company, Bishopsgate House, 80, Bishopsgate, E.C. 2. A fee of £1 1s. 0d. is charged, which cannot under any circumstances be returned.

Drawings may be had at the cost of the tenderer, by application to Messrs. Hodges, Bennett & Co. Ltd., 78, Queen Victoria Street, E.C. 4.

Tenders must be delivered at the Company's Offices not later than noon on Friday, the 24th February, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
OSWALD I. MILNE,
Secretary.

7th February, 1922. T 385

APPOINTMENTS OPEN.

CITY AND GUILDS (ENGINEERING) COLLEGE.

CHAIR OF ELECTRICAL ENGINEERING.

The Delegacy of the City and Guilds (Engineering) College invite

Applications for the Appointment

to the PROFESSORSHIP and HEAD of the DEPARTMENT OF ELECTRICAL ENGINEERING in the College, in succession to Professor T. MATHER, F.R.S., as from the commencement of the session 1922-3.

The College forms the Engineering Section of the Imperial College of Science and Technology and is conducted by a Delegacy representing the Imperial College, the City and Guilds of London Institute and the Goldsmiths' Company.

A copy of the terms and conditions attached to the appointment may be had on application to the SECRETARY to the Delegacy, City and Guilds (Engineering) College, Exhibition Road, London, S.W. T 394

BOROUGH OF WIMBLEDON.

APPOINTMENT OF CHIEF ELECTRICAL ENGINEER.

The Corporation of Wimbledon invite

Applications for the above

POSITION.

Particulars as to duties and conditions of service, and form of application, may be obtained from the undersigned.

Canvassing Members of the Council directly or indirectly will disqualify the Applicant.

Applications to be delivered to the undersigned not later than Saturday, 25th February, 1922.

A. STEELE SHELDON,
Town Clerk.

Town Clerk's Office,
12, Queen's Road,
Wimbledon, S.W. 19.
8th February, 1922. T 386

Civil Engineer Required

by the GOVERNMENT OF PALESTINE for one year's probationary service as an ASSISTANT ENGINEER in the PUBLIC WORKS DEPARTMENT with prospect of permanency. Salary 450 pounds Egyptian per annum, rising annually by 25 pounds Egyptian to 550 pounds Egyptian, with a temporary and reducible cost of living allowance amounting, at present, to 10 per cent. of the minimum salary plus 36 pounds Egyptian. Free passages.

2. Candidates, who must be unmarried and not over 30 years of age, must have passed Sections "A" and "B" of the A.M.Inst.C.E. examination or an equivalent exempting examination, and have had at least two years' experience as Assistant Engineer in charge of construction and maintenance of Buildings, Roads, Water Supply and Drainage.—Apply, at once, in writing, giving age and brief details of experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/Palestine 11324. T 416

Qualified Surveyor Required

for Central Africa. Sound knowledge of Tachometric Surveying and Field work in the Tropics essential.—Reply fully stating particulars of training, qualifications and experience, age and salary expected, to BOX L714, LEE & NIGHTINGALE, Advert. Offices, Liverpool. T 367

Engineer.—A General Engi-

neering Firm HAVE a VACANCY for an Experienced Designing Engineer, accustomed to gear work for steam turbines. Only those who have actually been in charge of design, and who possess good technical experience need apply. State full particulars of previous experience, age, and salary required.—Address, T 343, Offices of ENGINEERING.

Smart Commercial Engineer

WANTED, about thirty, to sell heavy Pulverizing Mills. Only capable men with good selling record need apply. Must be good correspondent. Good connection and experience with Collieries, Cement and Chemical Manure Works an advantage. Languages also advantageous. Write fully stating salary required, when free, etc.—Address, T 384, Offices of ENGINEERING.

Applications are Invited for

the POSITION of ASSISTANT POWER and ELECTRICAL ENGINEER. Applicants must be experienced in the erection, maintenance, and repair, in connection with Engineering Works Electrical Equipment, and must have had first-rate experience with boiler and engine house plant. Application should be made by letter stating experience, age, and salary required, and enclosing copies of three recent testimonials.—Address, T 222, Offices of ENGINEERING.

SHANGHAI MUNICIPAL COUNCIL.
PUBLIC WORKS DEPARTMENT.
APPOINTMENT
OF TWO ASSISTANT ENGINEERS.

Two Thoroughly Qualified

ASSISTANT ENGINEERS are REQUIRED in the Public Works Department.

(A) Candidates must be unmarried, not more than 30 years of age and should hold the testamur of the Institution of Municipal and County Engineers or have passed the examination for Associate Membership of the Institution of Civil Engineers for

(B) Hold a degree in Engineering from a University in Great Britain.

Salary, Taels 350 per mensem, without allowances, under a three years' agreement, with first class passage, half pay on voyage and free medical attendance. There is an excellent Superannuation Scheme.

(C) The value of the Tael at the present rate of exchange is about 3s. 6d., but it is liable to fluctuation. Taels 350 per mensem at exchange 3s. 4d. is equivalent to about £700 per annum, but the salary is payable in Taels without reference to rate of exchange.

Particulars of the appointment may be obtained from T 336

Messrs. JOHN POOK & CO.,
Agents for the Shanghai Municipal Council,
68, Fenchurch Street,
February, 1922. London, E.C. 3.

Naval Architect and Ship-

BUILDER WANTED, having long and wide experience in the design of small Craft, Paddle Boats, Sternwheelers, Launches, Dispatch Boats, etc. Preferably, applicant should not be under 40 years of age. Give full details, and state salary required.—Address, T 411, Offices of ENGINEERING.

Wanted, Two First-class

DRAUGHTSMEN accustomed to Gas Works Practice, Chemical Plant and General Constructional Engineering work.—Apply, stating age, experience, salary required and giving references, to T 387, Offices of ENGINEERING.

Draughtsman.—Vacancy

EXISTS for a MAN skilled in the design of Pipe Systems for the collection and conveying of materials, refuse from woodworking machines, grinding wheels and similar apparatus. He must be proficient in the theory of the subject. Able to determine sizes of pipes and shapes of hoods, which will accomplish the purpose with the minimum expenditure of energy on fans.—Address, "DESIGN," WM. PORTEOUS & CO., Advertising Agents, Glasgow. T 390

Chief Draughtsman Wanted;

must be a first-class structural steel designer with experience organising and managing a large drawing office making shop drawings for steel bridges, buildings, factories and supports for machinery according to latest efficiency methods of system, speed and economy, of draughting, manufacture and erection. Good position with old established engineering manufacturing company in London district for such a man, able to shoulder responsibility, manage efficiently a force of draughtsmen, and turn work out competitively.—Address, with full particulars, T 355, Offices of ENGINEERING.

Draughtsmen Required for

Large Works. Must be thoroughly conversant with structural steelwork detailing for heavy workshop buildings. Experienced men only need apply.—State age, qualifications, experience and salary expected.—Address, T 357, Offices of ENGINEERING.

Draughtsman (Young) Wanted

Immediately by Water Undertaking in the South of England, for three or four months' work only, to assist in preparing drawings for Filter Bed and Reservoir extensions of a simple character.—Address, stating age, qualifications and salary required, to T 409, Offices of ENGINEERING.

Boiler Supervisors Required.

Applicants must be trained Engineers with practical experience in the maintenance of Boiler plant and use of scientific instruments for obtaining efficiency in operation.

Apply in writing, stating salary required, to LEVER BROTHERS LTD., General Works Manager, Port Sunlight. T 372

Large Manufacturers of

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Civil Engineer, A.M.Inst.C.E.,

age 33, perfect Spanish, 16½ years' Railway experience on survey construction and maintenance, and on building construction. Will go abroad.—BOX 47, SCHIPP'S, South Molton St., W. 1. T 366

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Engineer, Scotsman, Ex-Captain R.E., age 35, SEEKS APPOINTMENT at home or abroad.

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THE RAPID CALCULATION OF FERRO-CONCRETE BEAMS.

By AUGUSTE ESNOUF, A.C.G.I., and LEON JOSEPH COUTANCEAU, A.C.G.I., A.M.I.C.E.

WE could have chosen as a starting point of this paper, formulæ one finds in all text-books dealing on ferro-concrete; as, however, these equations can be deduced easily from the fundamental laws of elastic deformation of solids, we have much preferred working them out radically; moreover, we have done so with the earnest desire of showing that ferro-concrete design has nothing empirical about it in any way.

The following list, explained by Fig. 1, gives the meaning of the symbols which we make use of throughout this paper.

Let M = Bending moment at section under consideration.
h = Effective depth of beam; *i.e.*, the distance of the centre of gravity of tensile reinforcement to the compressive edge of the beam.
e = Thickness of slab.
e' = Effective depth of slab; *i.e.*, the distance of the centre of gravity of tensile reinforcement from the compressive edge of slab.
b = Width of slab acting with the rib. (Generally three-quarters of the distance from centre to centre of ribs.)
y = Distance of the neutral axis from the compressive edge of slab.
S = Total cross-section of tensile reinforcement.

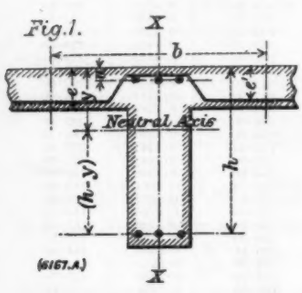


Fig. 1.

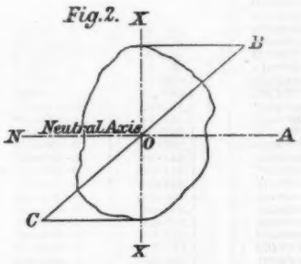


Fig. 2.

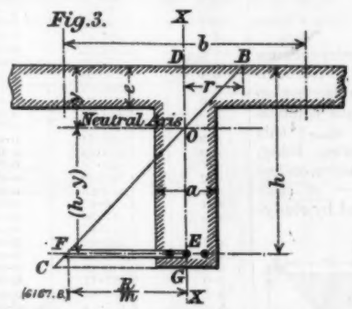


Fig. 3.

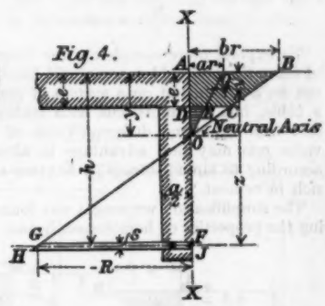


Fig. 4.

S′ = Total cross-section of compressive reinforcement.
u = Distance of the centre of gravity of compressive reinforcement from the compressive edge of beam.
m* = Ratio of the modulus of elasticity of steel to that of concrete.
R = Mean working stress of steel.
r = Maximum working stress of concrete; *i.e.*, stress at the most compressed fibre.

Navier's law states that: When a solid is subjected to bending, each fibre is deformed elastically (lengthened or shortened) proportionally to its distance from the neutral fibre or neutral axis.

To express graphically this truth, let us take, on the cross-section of the solid subjected to bending (Fig. 2), an axis X X perpendicular to the neutral axis A N and mark off the amount of deformation as ordinates on either side of X X; *i.e.*, compressions to the right and elongations to the left; we shall evidently obtain the slanting straight line B O C, passing through O, the point of intersection of X X and the neutral axis A N. On the other hand, Young's law states that the rate of deformation of any fibre, elastically elongated or compressed, is directly proportional to the working stress of the fibre and inversely proportional to the modulus of elasticity of the substance of which the fibre is made. Combining the two laws, we see that:—

1. In an homogeneous solid elastically bent, the working stress of each fibre is directly proportional to its distance from the neutral axis.

It follows then that for such a solid, the straight line B O C (Fig. 2) represents the graph to a certain scale of the working stress of the different fibres; compressions being measured on the right and tensions on the left of X X.

2. In an heterogeneous solid elastically bent, the working stress of each fibre is proportional, directly to its distance from the neutral axis and inversely to the modulus of elasticity of the substance forming the fibre. Here also the straight line B O C (Fig. 2) can be taken to represent the working stress of the different fibres, taking care, however, that the working stress must be measured on different scales for each different substance forming the solid, the relation of the scales between themselves being the reciprocal to that of their respective moduli of elasticity. For example, if our solid is made up of concrete and steel, the scale of the working stress of steel will be $\frac{1}{m}$ that of the working stress of concrete. We are now able to consider the study of a ferro-concrete beam, and to begin with, we will take a—

T-BEAM WITHOUT COMPRESSIVE REINFORCEMENT AND WHOSE NEUTRAL AXIS IS OUTSIDE THE SLAB.*

Working Stress.—The working-stress diagram will be, as previously explained, the straight line B O C (Fig. 3.)

The working stress of the compressed concrete will reach its maximum value r at the top edge of the slab where it can be measured to scale by the ordinate D B; it will then decrease to zero at the point O; from this point to the bottom of the beam, the concrete will be subjected to tensile stresses, the rate of which will increase from 0 to a maximum value measured by C G. As for the working stress of the steel, it will also be given by the straight line B O C, but measuring the ordinates to a scale which is $\frac{1}{m}$ that adopted for the working stress of the concrete, we shall have the relation†

$$E F = \frac{R}{m}$$

From Fig. 3, then, we have the following relation:

$$y : h = r : \left(r + \frac{R}{m}\right)$$

whence

$$y = \frac{m r}{R + m r} . h \quad . \quad . \quad . \quad (1)$$

Resisting Forces.—It is convenient at first to notice that, in the calculations, the resistance of concrete to tension is not taken into consideration. The diagram of resistance of the beam then reduces itself to the following elements. (Fig. 4.)

1. The trapezium A B C D, representing the resistance of the slab to compression, and whose area is equal to the cross-section of the slab ($b e$) multiplied by the mean working stress of the slab which is

$$\left(r . \frac{y - \frac{e}{2}}{y}\right) \text{ giving } b e r \left(1 - \frac{e}{2y}\right)$$

as the total resistance.

2. The triangle D E O, representing the resistance of the compressed portion of the rib, this element is relatively of so little importance that it may be nearly always neglected, we only mention it for the take of accuracy, although we will not take it into consideration in the calculations which follow.

3. The trapezium F G H J, representing the resistance of the tensile reinforcement, *i.e.*, R S. Since the beam is in equilibrium, the algebraic sum of forces acting at any section equals zero, we can thus write, neglecting item 2.

$$b e r \left(1 - \frac{e}{2y}\right) - R S = 0$$

$$\text{or } b e r \left(1 - \frac{e}{2y}\right) = R S \quad . \quad . \quad . \quad (2)$$

Points of Application of Resisting Forces.—Each of the two kinds of resisting forces, represented in magnitude by the areas of corresponding surfaces of Fig. 4, can be replaced by a single force or resultant of same magnitude acting at the centre of gravity of these surfaces.

The total resistance of the slab to compression will be replaced by a resultant acting at the point Q (Fig. 4), whose distance from the top edge of the slab will be:

$$V = \frac{3 e y - 2 e^2}{6 y - 4 e}$$

As for the resistance of the tensile reinforcement, it acts evidently at the centre of gravity of the reinforcing bars, *i.e.*, at a distance h from the top edge of the slab.

Moment of Resistance.—The moment of resistance of the beam at the section considered will be the algebraic sum of the moments of the elastic forces we have just enumerated, about any horizontal axis situated in the plane of that section.

Let us take, for example, the moments about an axis passing through the centre of gravity of the tensile reinforcement, the moments of resistance of these reinforcements will be zero, and we have as total moment M, the moment of resistance of the compressed slab M, and this we will write:

$$M_1 = b e r \left(1 - \frac{e}{2y}\right) \times Z = b e r \left(1 - \frac{e}{2y}\right)(h - v) \quad (\textit{Fig. 4})$$

or

$$M_1 = b e r \left(1 - \frac{e}{2y}\right)\left(h - \frac{3 e y - 2 e^2}{6 y - 3 e}\right) \quad . \quad . \quad (3)$$

Writing y in terms of h by means of equation (1), we have

$$M_1 = b e r \left(h - e . \frac{R + 2 m r}{2 m r} + \frac{e^2}{h} . \frac{R + m r}{3 m r}\right)$$

Since $M = M_1$ we can write

$$\frac{M}{b e r} = h - e . \frac{R + 2 m r}{2 m r} + \frac{e^2}{h} . \frac{R + m r}{3 m r} \quad . \quad (4)$$

From this equation one can easily determine any of the variables if the other variables are known. R the working stress of steel is always known; as it is economical to reduce to the minimum the weight of the tensile reinforcement, R is taken as great as possible, namely, the working stress usually taken for the steel that is to be employed:—

m is fixed beforehand for the kind of transverse reinforcement adopted.
b is fixed beforehand from the centre to the centre of ribs.
e, the thickness e of the slab generally given by the calculation of resistance of the slab between two consecutive beams, a calculation that precedes that of the beam.
M is generally the datum of the problem,

* m has a value of $\frac{E_t}{E_c}$ which varies from 8 to 15, depending on the precautions taken to prevent deformation of concrete in a direction at right angles to the plane of bending. English authors take generally $m = 15$; M. de Tédesco advises to take $m = 12$ and arrange the transverse reinforcement so that this value of m is not exceeded. Useful informations on this point will be found in the "Circulaire Ministérielle" of October 20, 1906, which is, as a whole, an invaluable source of information for all concerned in ferro-concrete.

* It is pointed out later that, T-beams with the neutral axis in the slab, rectangular beams and slabs, can be considered as particular cases of this first type of beam.

† It is to be noticed that the extreme stresses (working) of the tensile reinforcement, concentrated on a very small depth are very near the mean working stress; so that one may adopt for R the normal working stress of steel which can only result in diminishing very slightly the factor of safety for the most elongated fibres of the reinforcement.

depending on a known quantity such as loading, &c. It is only for verification of an already constructed beam that M becomes the unknown quantity.

Of the last variables h and r, one or the other will be unknown, depending whether an arbitrary height h of a beam be chosen or a maximum working stress r of concrete fixed upon. We will first study the second case, the one in which r is given and h is the unknown quantity. Equation (3) having the unknown h to the second power, one has to solve a quadratic which is rather complex considering the numerical coefficients it contains. The difficulty, however, can be got over, and the value of h obtained rather rapidly, and with sufficient accuracy, by means of successive approximations, or again by substituting for the quadratic equation (3)*, a linear equation giving between the limits of practical application, values of h in sufficient agreement with its exact values. These simplifications, however, have not satisfied us, our desire being to prepare graphs or a table (which are, in fact, but two different ways of expressing the same thing), which would give us at a glance the value of h.

We will assume first that every engineer will adopt certain fixed values for R, r and m; once these quantities are fixed, one can consider that there remain but three interdependent variables, *i.e.*,

$$\frac{M}{b}, \quad e \text{ and } h.$$

To express more completely the interdependence of these three variables, one would have to fall back not on a graph, but on a system of graphs, not on a table, but on an Abacus with multiple columns and this for every different value of r_{max}; this value one may find advantage in altering, using, according to circumstances, a mixture more or less rich in cement.

The simplification we sought was found by studying the properties of homologous beams.

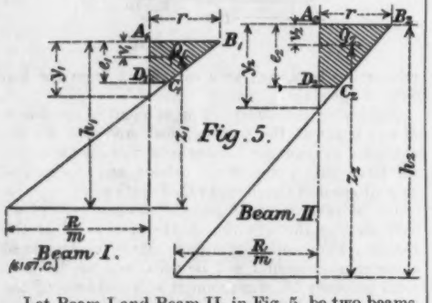


Fig. 5.

Let Beam I and Beam II, in Fig. 5, be two beams, of heights h_1 and h_2 respectively, and whose slabs have respective thicknesses of e_1 and e_2, so that $h_1 : e_1 :: h_2 : e_2$. (In both beams, however, R, r and m are constant.)

Then $A_1 D_1 : A_2 D_2 :: e_1 : e_2 :: h_1 : h_2$.

The areas of these trapeziums are to one another in the proportion $A_1 B_1 C_1 D_1 : A_2 B_2 C_2 D_2 :: h_1 h_2 :: e_1 : e_2$. Also

$$\frac{y_1}{y_2} = \frac{h_1}{h_2} = \frac{e_1}{e_2} \text{ and } \frac{z_1}{z_2} = \frac{h_1}{h_2} = \frac{e_1}{e_2}.$$

The moment of the compressive stresses about the centre of the tensile reinforcement, identical with the total moment of resistance of the beam is given by the product of the area A B C D by the lever arm Z, and also by the effective breadth of the slab; the moments of resistance of the two beams under consideration are then:

$M_1 = A_1 B_1 C_1 D_1 \times Z_1 \times b_1$ and $M_2 = A_2 B_2 C_2 D_2 \times Z_2 \times b_2$

whence it follows that:

$$\frac{M_1}{b_1} : \frac{M_2}{b_2} :: h_1^2 : h_2^2 :: e_1^2 : e_2^2.$$

Consequently, all beams homologous between themselves, or those having a ratio $\frac{h}{e}$ = constant (ratio we will hence call the "index of section") will have resistances proportional to the square of their heights (or what comes to the same thing, to the square of the thickness of their slab) and to the useful breadth of that slab. We will confirm algebraically this deduction in considering equation (4), which we will rewrite after every term has been multiplied by r and divided by e.

$$\frac{M}{b e^2} = r \cdot \frac{h}{e} - \frac{R + 2mr}{2m} + \frac{e}{h} \cdot \frac{R + mr}{3m} \quad . \quad (5)$$

from which we will see that for some value of

$$\frac{h}{e}; \frac{M}{b} \propto e^2$$

Representing then, the Index of section $\frac{h}{e}$ by the symbol i, we can rewrite equation (5) thus:

$$\frac{M}{b e^2} = ri - \frac{R + 2mr}{2m} + \frac{1}{i} \cdot \frac{R + mr}{3m} \quad . \quad (6)$$

In this equation we will notice that all the terms with i do not contain any of the independent variables $\frac{M}{b}$ and e, and that, moreover, these two independent variables are grouped in only one term of the equation. If, then, we adopt i instead of h as the argument, it is very easy for us to prepare a table giving for every value of i the corresponding value of $\frac{M}{b e^2}$; in possession of this table it will be then quite easy, when we have calculated $\frac{M}{b e^2}$ from the data of an example to find the corresponding value of i and consequently of h, since $h = e\,i$.

These values have been calculated in Table I, for $r = 700$ lb.-in.^{2}, or as we have taken it for a

TABLE I.—FOR THE DESIGN OF ⌐ OR T-BEAMS WITHOUT COMPRESSIVE REINFORCEMENT AND WITH THE NEUTRAL AXIS OUTSIDE THE SLAB. (FIGS. 1, 2 AND 3.)

In this table R = 15,624 lb./in.^{2} . $m = 12$. M is always expressed in foot-pounds, b in feet, e and h in inches, S in square inches.

$r = 700$ lb./in.^{2}, for a mixture of 4 : 6 : 12.
$r = 500$ lb./in.^{2}, for a mixture of 3 : 6 : 12.

$y = \frac{1}{2 \cdot 86} h = 0 \cdot 35\, h$ for a mixture of 4 : 6 : 12.

$y = \frac{1}{3 \cdot 325} h = 0 \cdot 3008\, h$ for a mixture of 3 : 6 : 12.

Values of $\frac{h}{e} = i$	Mixture 4 : 6 : 12. Where $y > e$. Superior Limit Values of $\frac{M}{b e^2}$	Mixture 4 : 6 : 12. $S = K \frac{M}{h}$ in Sq. In. Values of K.	Mixture 3 : 6 : 12. Where $y > e$. Superior Limit Values of $\frac{M}{b e^2}$	Mixture 3 : 6 : 12. $S = K \frac{M}{h}$ in Sq. In. Values of K.	When $y = e$. Inferior Limit Values of $\frac{M}{b e^2}$ or $\frac{M}{b y^2}$	$R = \frac{M}{b e^2} \cdot A + B$, Lb./Sq. in. Values of A.	Values of B.
2·86	884·34	0·0008694	—	—	884·33	0·50593	252·59
2·9	909·10	0·00086935	—	—	879·43	0·4964	248·81
3·0	971·45	0·0008689	—	—	868·00	0·4737	239·84
3·1	1,034·28	0·0008681	—	—	857·67	0·4530	231·48
3·2	1,097·54	0·0008670	—	—	844·57	0·4340	223·67
3·3	1,161·22	0·0008658	—	—	839·70	0·4165	216·36
3·325	1,177·20	0·0008655	837·64	0·0008537	837·64	0·4123	214·61
3·4	1,225·28	0·0008644	875·52	0·0008536	831·83	0·4003	209·51
3·5	1,289·67	0·0008629	926·30	0·0008532	824·60	0·3853	202·60
3·6	1,354·37	0·0008614	977·38	0·0008526	817·92	0·3714	197·00
3·7	1,419·36	0·0008599	1,028·72	0·0008519	811·74	0·3584	191·29
3·8	1,484·62	0·0008583	1,080·31	0·0008510	806·00	0·3463	185·89
3·9	1,550·11	0·0008568	1,132·12	0·0008501	800·66	0·3350	180·78
4·0	1,615·83	0·0008551	1,184·14	0·0008490	795·67	0·3243	175·95
4·1	1,681·76	0·0008536	1,236·36	0·0008480	791·00	0·3143	171·36
4·2	1,747·89	0·0008520	1,288·75	0·0008469	786·63	0·3049	167·00
4·3	1,814·20	0·0008505	1,341·32	0·0008457	782·54	0·2961	162·86
4·4	1,880·67	0·0008491	1,394·04	0·0008446	778·65	0·2877	158·92
4·5	1,947·30	0·0008476	1,446·90	0·0008435	775·00	0·2798	155·16
4·6	2,014·07	0·0008462	1,499·95	0·0008423	771·54	0·2726	151·57
4·7	2,080·99	0·0008448	1,553·03	0·0008412	768·30	0·2652	148·15
4·8	2,148·03	0·0008435	1,606·29	0·0008401	765·21	0·2584	144·87
4·9	2,215·10	0·0008422	1,659·65	0·0008390	762·28	0·2520	141·74
5·0	2,282·47	0·0008409	1,713·11	0·0008379	759·50	0·2465	138·74
5·1	2,349·85	0·0008397	1,766·68	0·0008369	756·86	0·2401	135·87
5·2	2,417·33	0·0008385	1,820·34	0·0008358	754·34	0·2345	133·10
5·3	2,484·91	0·0008373	1,874·09	0·0008348	751·93	0·2292	130·44
5·4	2,552·58	0·0008362	1,927·92	0·0008338	749·64	0·2241	127·89
5·5	2,620·33	0·0008351	1,981·83	0·0008328	747·45	0·2193	125·44
5·6	2,688·16	0·0008340	2,035·82	0·0008319	745·41	0·2146	123·08
5·7	2,756·08	0·0008330	2,089·87	0·0008309	743·34	0·2102	120·81
5·8	2,824·06	0·0008319	2,143·99	0·0008300	741·42	0·2059	118·62
5·9	2,892·11	0·0008310	2,198·19	0·0008291	739·57	0·2018	116·50
6·0	2,960·22	0·0008300	2,252·43	0·0008283	737·81	0·1976	114·46
6·1	3,028·40	0·0008291	2,306·74	0·0008274	736·08	0·1940	112·49
6·2	3,096·63	0·0008282	2,361·10	0·0008266	734·46	0·1903	110·59
6·3	3,164·93	0·0008273	2,415·50	0·0008258	732·89	0·1868	108·75
6·4	3,233·27	0·0008264	2,469·96	0·0008250	731·37	0·1834	106·97
6·5	3,301·67	0·0008256	2,524·58	0·0008242	729·91	0·1801	105·24
6·6	3,370·11	0·0008248	2,579·03	0·0008234	728·50	0·1770	103·57
6·7	3,438·60	0·0008240	2,633·62	0·0008227	727·14	0·1739	101·96
6·8	3,507·14	0·0008232	2,688·26	0·0008220	725·83	0·1710	100·39
6·9	3,575·72	0·0008225	2,742·94	0·0 008213	724·56	0·1681	98·87
7·0	3,644·34	0·0008217	2,797·66	0·0003206	723·34	0·1654	97·62
7·1	3,712·99	0·0008210	2,852·40	0 0008199	722·15	0·1627	95·96
7·2	3,781·69	0·0008203	2,907·19	0·0008193	721·00	0·1601	94·57
7·3	3,850·49	0·0008196	2,962·01	0·0008186	719·89	0·1576	93·22
7·4	3,919·18	0·0008190	3,016·86	0·0008180	718·81	0·1552	91·91
7·5	3,987·98	0·0008183	3,071·74	0·0008174	717·44	0·1528	90·63
7·6	4,056·81	0·0008177	3,126·65	0·0008168	716·76	0·1505	89·39
7·7	4,125·67	0·0008171	3,181·59	0·0008162	715·78	0·1483	88·18
7·8	4,194·55	0·0008165	4,226·56	0·0008156	714·83	0·1461	87·01
7·9	4,263·47	0·0008159	3,291·55	0·0008151	713·90	0 1441	85 86
8 0	4,332·42	0·0008153	3,346·57	0·0008145	713·00	0·1420	84·75
8·1	4,401·39	0·0008148	3,401·61	0·0008140	712·13	0·1400	83·66
8·2	4,470·38	0·0008142	3,456·68	0 0008135	711·28	0·1381	82·60
8·3	4,539·40	0·0008137	3,511·77	0·0008129	710 46	0 1362	81·57
8·4	4,608·44	0·0008131	3,566·88	0·0008124	709·65	0·1344	80·56
8·5	4,677·51	0·0008126	3,622·01	0·0008119	708·87	0 1326	79·58
8·6	4,746·60	0·0008121	3,677·16	0·0008115	708·11	0·1309	78·62
8·7	4,815·71	0·0008116	3,732·33	0·0008110	707·36	0·1292	77·68
8·8	4,884·83	0·0008112	3,787·52	0·0008105	706·64	0·1276	76·77
8·9	4,953·98	0·0008107	3,842·73	0·0008101	705·94	0 1260	75·87
9·0	5,023·15	0·0008102	3,897·95	0·0008096	705·25	0·1244	75·00
9·1	5,092·33	0·0008098	3,953·19	0·0008092	704·58	0·12299	74·13
9·2	5,161·54	0·0008093	4,008·45	0·0008088	703·93	0·1214	73·31
9·3	5,230·76	0·0008089	4,063·73	0·0008084	703·29	0·1200	72·50
9·4	5,299·99	0·0008085	4,119·04	0·0008080	702·67	0·1186	71·68
9·5	5,369·25	0·0008081	4,174·32	0·0008076	702·06	0·1172	70·92
9·6	5,438·51	0·0008077	4,229·64	0·0008072	701·47	0 1158	70·76
9 7	5,507·80	0·0008073	4,284·98	0·0008068	700·89	0 1145	69·25
9·8	5,577·10	0·0008069	4,340·37	0·0008064	700·31	0·1132	68·68
9·9	5,646·41	0·0008065	4,395·69	0·0008060	699·76	0·1119	67·96
10·0	5,715·70	0·0008061	4,451·06	0·0008057	699·22	0·1107	67·26
∝					651·00		

* *Vide* Appendix.

mixture of 4 : 6 :: 12 and $r = 560$ lb./in.², or as we have taken it for a mixture of 3 : 6 : 12.

This result can also be shown graphically. We must here point out that in order to observe the conditions we have set to ourselves in studying this first problem, *i.e.*, so that the neutral axis should be outside the slab, y must be greater than e, or just equal to e, *i.e.*, making use of equation (1):

$$h \cdot \frac{m r}{R + m r} \geqq e \quad \text{or} \quad \frac{h}{e} \geqq \frac{R + m r}{m r}$$

$$\therefore i \geqq \frac{R + m r}{m r}$$

Our tables must not contain values of i smaller than $\frac{R + m r}{m r}$. We have chosen $R = 15{,}624$ lb./in.² and $m = 12$. Also for a mixture of 4 : 6 : 12 ; $r = 700$ lb./in.² whence $i \geqq 2{\cdot}86$, and for a mixture of 3 : 6 : 12 ; $r = 560$ lb./in.² whence $i \geqq 3{\cdot}325$.

If our data are such that $\frac{M}{b e^2}$ is smaller than the smallest value contained in our table or indicated by the curve, the beam will not have the neutral axis outside the slab, and the problem cannot be solved by using these first tables or curves.

We will now study the case when h is known, and call it the case of a beam of arbitrary height.*

After taking a certain height h one can find r by the relation:

$$r = \frac{\frac{M}{b} + \frac{e^2 \cdot R}{2 m} - \frac{e^3 \cdot R}{3 m h}}{e h + \frac{e^3}{3 h} - e^2} \quad . \quad . \quad . \quad (7)$$

taken from equation (4).

This determination of r is more easily reached by rewriting equation (6) thus:

$$r = \frac{M}{b e^2} \cdot \frac{6 i m}{2 m (3 i^2 - 3 i + 1)} + \frac{R (3 i - 2)}{2 m (3 i^2 - 3 i + 1)} \quad . \quad (8)$$

Calling

$$\frac{6 i m}{2 m (3 i^2 - 3 i + 1)} = A \text{ and } \frac{R (3 i - 2)}{2 m (3 i^2 - 3 i + 1)} = B$$

Equation (8) can be re-written thus:

$$r = \frac{M}{b e^2} \cdot A + B$$

The two terms A and B have been calculated for each value of i thus making the calculation of r rapid and easy.

This can also be given graphically.

In calculations, the determination of r is only useful: (1) To make sure that the limiting value of the working stress of the concrete has not been exceeded; (2) to verify that the neutral axis falls outside the slab by means of equation (1): $y = \frac{m r}{R + m r} \cdot h$; (3) to calculate the section of tensile reinforcement. But with the methods we have developed, it is absolutely useless to determine r, the three aims for which this determination can be useful, being arrived at otherwise, as follows:

1. If we have a certain i for a beam, and we also calculate its $\frac{M}{b e^2}$, then if $\frac{M}{b e^2}$ is less than the superior limit value corresponding to the i of our beam, r will be smaller than the initial r, and the beam will be working in good conditions of resistance as regards the compressed concrete. If, on the contrary, for the value of i we find that $\frac{M}{b e^2}$ calculated is greater than the superior limiting value of i for the beam, then h is too small, and we must either increase the value of h or fall back on a beam requiring steel in compression which case will be considered later on, but is always at a disadvantage where economy is considered. A third method would consist in increasing e up to its limit value, *i.e.*, when $e = y$, but the gain in the resisting moment would be out of proportion to the extra expenditure of concrete.

2. To verify that the neutral axis falls outside the slab we must remember that the condition that must be fulfilled is that:

$$i \geqq \frac{R + m r}{m r} \text{ which can also be written as } r \geqq \frac{R}{m (i - 1)}$$

Introducing this value of r in equation (6) we find, after simplifying that at the limiting values of:

$$\frac{M}{b e^2} \text{ we have } y = e \geqq \frac{R (3 i - 1)}{6 m (i - 1)}$$

The value of the expression $\frac{R (3 i - 1)}{6 m (i - 1)}$ for every value of i has been calculated in Table I and gives at sight, the inferior limit values of $\frac{M}{b e^2}$ corresponding to each i which, as defined above, decides the ratio $\frac{h}{e}$.

If, then, we choose a certain i for a beam, and calculate its $\frac{M}{b e^2}$, if the calculated $\frac{M}{b e^2}$ is less than the inferior limit values of $\frac{M}{b e^2}$ for the corresponding i, then the neutral axis falls inside the slab and the beam thus arbitrarily chosen must be treated accordingly.

Advantage of these inferior limit values of $\frac{M}{b e^2}$ can be taken to give the limits under which the curves of $\frac{M}{b e^2}$ are not to be worked to.*

(To be continued.)

ELECTRO-PNEUMATIC DECKING PLANT FOR COLLIERY SHAFTS.

(Concluded from page 96.)

OUR description of the Thurcroft Colliery installation has so far concerned itself only with the plant at the pit head, but it will be clear that full advantage will not be obtained from the electro-pneumatic gear unless a generally similar gear is installed at the pit bottom. If the head gear alone were used, all the advantages of interlocking and safety which we have described would be operative, but the speeding-up features would always be limited by the conditions underground. A cage newly arrived at the surface cannot be got away again until the necessary unloading and re-loading has been carried out not only at the pit top but at the pit bottom. The underground installation which is now being installed at the Thurcroft Colliery does not differ in essentials from the pit-bank gear, but the complete installation is a somewhat less complicated one, and various details are of somewhat different type. A diagram of the gear is given in Fig. 40, subjoined.

As this gear in its general features resembles the pit head gear, which we have already described very fully, it will not be necessary to follow the diagram through in every detail. A general and brief description may, however, be given, directing attention especially to the detail features in which it departs from the pit head arrangement. A comparison of Fig. 40 with our earlier Fig. 4, which shows the pit head connections, will at once make it clear that the underground gear is considerably simpler than that at the bank. This arises mainly from the fact that no kep mechanism is required underground and that the hoist arrangement is different. Full tub drop cages are fitted, but are a short distance from the main cage, a runway extending from the main cage upper deck to the drop cages. No cages are required on the onsetter's side as tubs are gravitated down to either deck level of the main cage. Pneumatic tub-retarders controlled by a hand valve are being installed to control the speed at which tubs gravitate from the main roads down to the decking rams. A further feature which simplifies Fig. 40 somewhat as compared with Fig. 4 is that in the underground installation a different type of ram is used for loading and unloading the cage. The pit-head ram, which it will be remembered carries two pushers from a cross-head and unloads the two decks of the cage, is not of the standard construction employed by the Westinghouse Brake and Saxby Signal Company, and was not built by them. This ram was in use at the colliery before the electro-pneumatic installation was made, and has been adapted to work in with the other gear.

The standard unloading ram of the Westinghouse Brake Company is of the type indicated at 24 and 25,

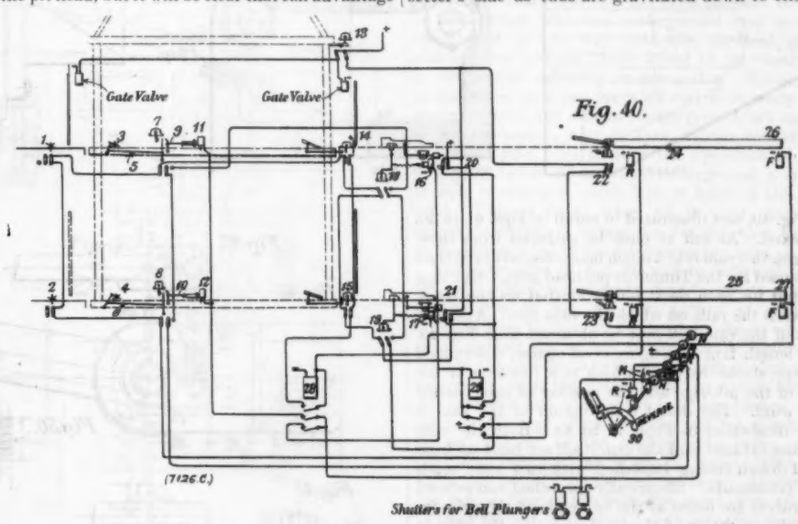


Fig. 40.

TABLE OF REFERENCES.

1 and 2. Six-star axle counter geared to contact box.
3 and 4. Six-star tub controllers which lock automatically after passing six axles.
5 and 6. Rocker shafts and bars fixed to main cage and used to unlock tub controllers 3 and 4.
7 and 8. Contact boxes which indicate when tub controllers 3 and 4 are unlocked.
11 and 12. 3-in. × 2½-in. Electro-pneumatic motors which unlock tub controllers 3 and 4.
13. Contact box which makes circuits when cage comes level and causes gates to be lifted, and interlocking circuits made ready for operating tub controllers and rams.
14 and 15. Contact boxes to prove back axle stops are up behind tubs.
16 and 17. E. P. motors operating rail skotch blocks in front of tubs.
18 and 19. Contact boxes detecting whether skotch blocks are "on" or "off" the rails.
20 and 21. Contact boxes for reversing rams. These boxes are operated by the ram cross-heads as soon as the forward stroke is complete.
22 and 23. Contact boxes detecting rams in back position. These boxes ensure that the ram returns the full stroke and thus picks up the correct number of tubs before making another forward stroke.
24 and 25. Electro-pneumatic rams. Approx. 16 ft. stroke for three tubs per deck cages: approx. 11 ft. stroke for two tubs per deck cages.
26 and 27. E. P. valves controlling admission of air for forward stroke of rams.
28 and 29. Ram control relays.
30. Onsetter's control lever with electric lever locks and contact box controlling ram circuits.

* Taking economy into consideration, we must always, as far as possible, give to h a value greater than the minimum value found from Table I as explained in the earlier part of this article.

* It is to be noticed that $\frac{M}{b e^2}$ can be made so small that a beam with the neutral axis outside the slab can not be constructed at all. For the condition

$$\frac{M}{b e^2} \geqq \frac{R (3 i - 1)}{6 m (i - 1)}$$

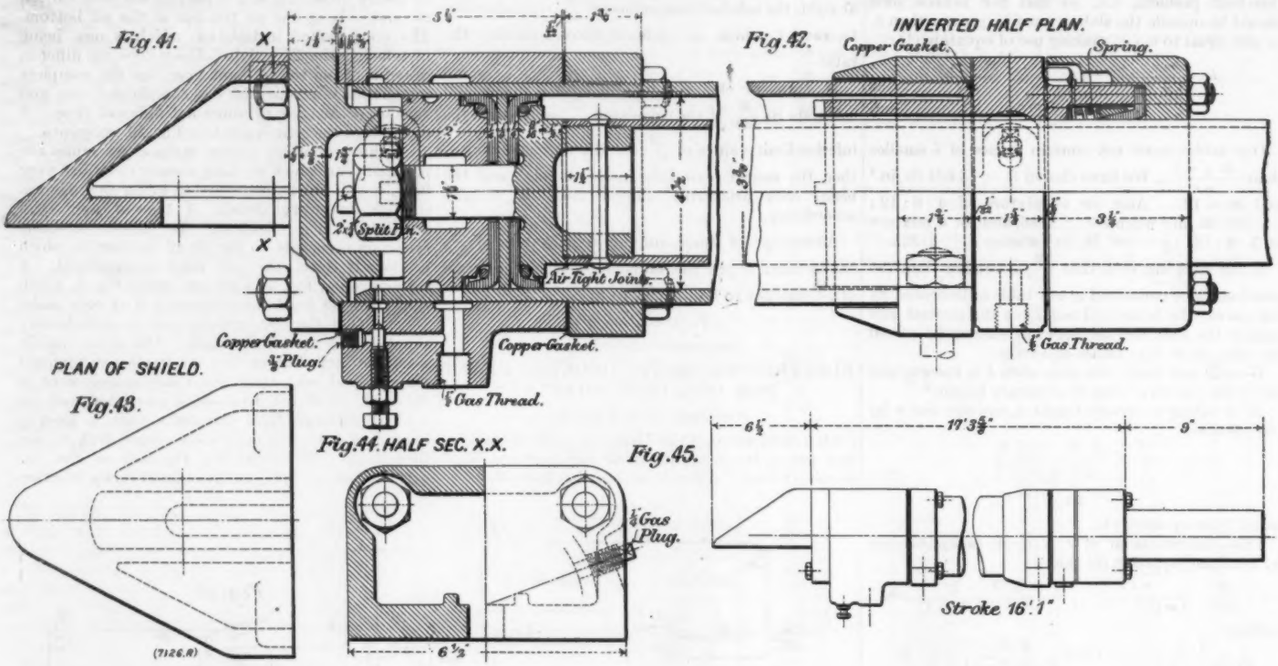
can also be written

$$\frac{M}{b e^2} \geqq \frac{R}{2 m} + \frac{R}{3 m (i - 1)}.$$

By putting then $i = \infty$, the second term $\frac{R}{3 m (i - 1}$ becomes 0, and we have $\frac{M}{b e^2} \geqq \frac{R}{2 m}$ which is the smallest value of $\frac{M}{b e^2}$ when $h = \infty$ and neutral axis is on the point of falling outside the slab.

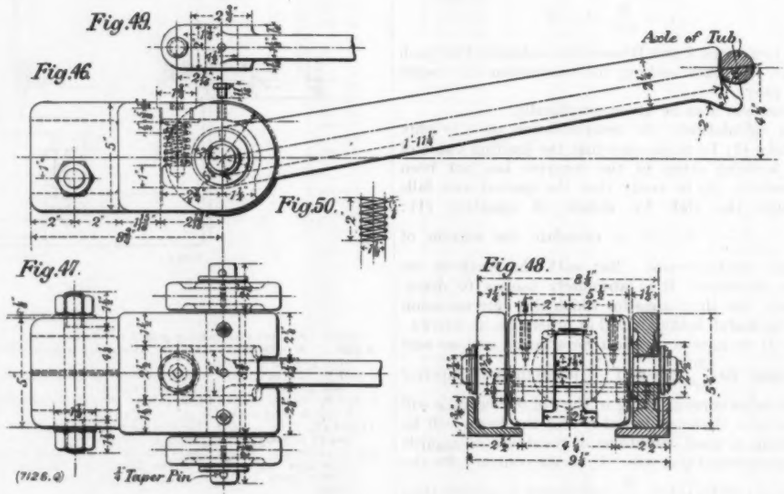
ELECTRO-PNEUMATIC DECKING PLANT FOR COLLIERY SHAFTS.

CONSTRUCTED BY THE WESTINGHOUSE BRAKE AND SAXBY SIGNAL COMPANY, LIMITED, ENGINEERS, LONDON.



in Fig. 40, and illustrated in detail in Figs. 41 to 50, annexed. As will at once be gathered from these figures, this ram is of a much more compact type than that used for the Thurcroft pit-head gear. One ram is used for each deck and is located on the track between the rails on which the tubs run. A general idea of the ram will best be obtained from Fig. 45. The length L of that figure is, of course, determined by the stroke required which is a function of the size of the pit cage and the number of tubs carried per wind. The detail construction of the ram is well illustrated in Figs. 41 to 44. Both the containing cylinder and the ram itself are built up from solid drawn tubing furnished with cast steel heads and crossheads. Electrically-controlled compressed air valves are fitted at the two ends of the cylinder and the operation of these valves causes the ram to move forward or reverse. The interworking of these valves with the control gear follows the general lines of the similar arrangements we have already dealt with. It will be clear that on its forward stroke when it is pushing the tubs the ram is subjected to pressure over the full area of the piston. On the return stroke the working area is only the difference between the cylinder area and the ram area. On the return stroke no work is, of course, being done other than in overcoming friction.

As will be seen from Figs. 41, 43 and 45, the back end of the ram cylinder is fitted with a hood or shield. The purpose of this is to form an easy lead for chains hanging from the tubs. If this hood was not fixed the chains might catch on the cylinder cover nuts with consequent breakage or derailment. The front end of the ram carries a pusher for driving the tubs. This is not indicated in Fig. 45, but is illustrated in detail in Figs. 46 to 50. As will be clear the arrangement consists of a spring-supported arm which engages with the rear axle of the line of tubs which is being pushed. When the ram is at rest and tubs are being run forward into position ready for the next push stroke the axles approach the pusher from behind and depress it as they pass, when, however, the ram moves forward and the pusher engages the rear axle, the direction of the thrust maintains it in position so that the tubs are propelled. The front end of the ram, which, of course, overhangs considerably from the cylinder when it is in its forward position, is supported on

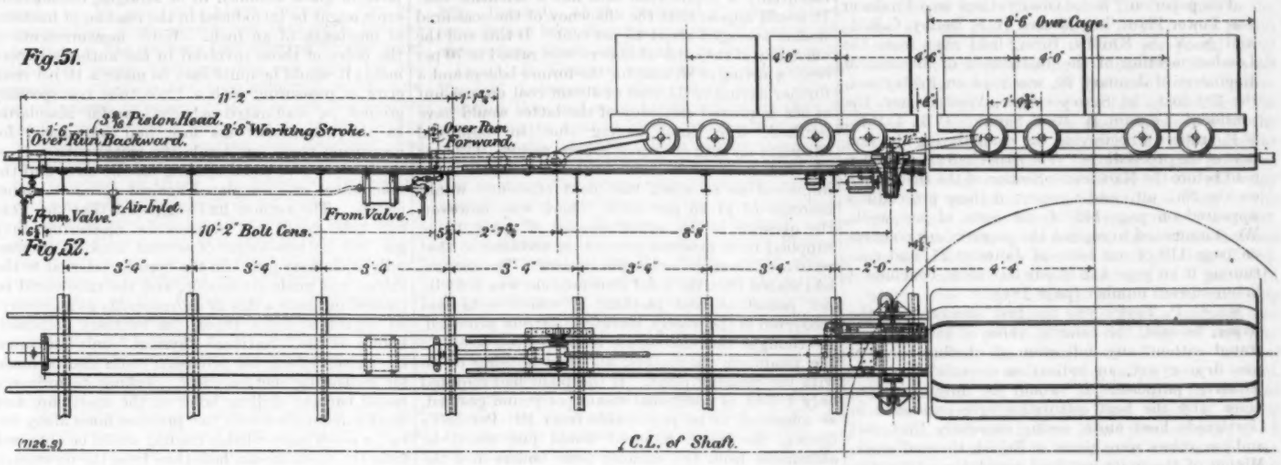


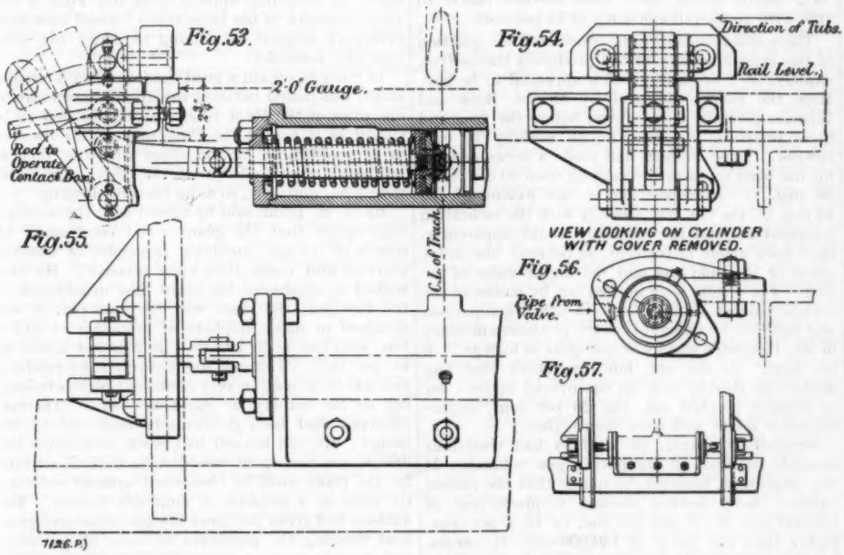
a pair of rollers carried on either side of the crosshead and running on a short track fixed between the main rails. The action of the whole arrangement will be well understood from Figs. 51 and 52, on page 159. This shows a complete pusher gear lay-out. The arrangement is not that of the Thurcroft installation, in which three tubs form a batch instead of the two shown in Figs. 51 and 52, but the lay-out clearly illustrates the standard pusher gear.

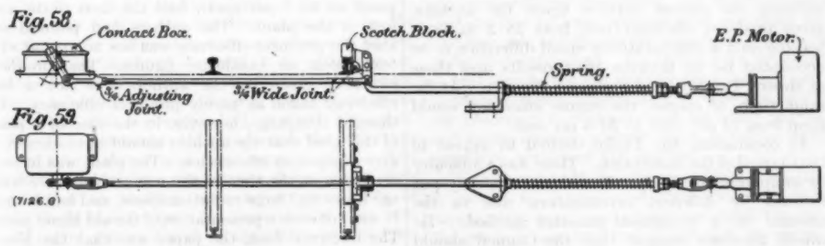
In connection with control of these rams the following point may be mentioned, as it required very special attention in design. The ram will be on full load on the forward stroke but on light load on the return, and, although the differential piston provides correct power for the move in each direction, it is essential that there shall be no pause in the extreme forward position before reversal takes place. To get this quick reversal a small reservoir is fixed under the ram, and the reverse valve admits air from this reservoir to the front end of the piston. This reservoir is fed from the air main through a restricted orifice, so that pressure in the reservoir builds up comparatively slowly while the ram is at rest or during the pushing-out stroke. The pressure in the reservoir equals the main's pressure before the ram reaches the end of this stroke. When the reverse valve is energised, the front end of ram is opened to this reservoir and is therefore subjected to the main's pressure immediately and starts to move back rapidly. The reservoir capacity is such that after the ram has travelled back 3 ft. the pressure is reduced sufficiently to finish the backward stroke at slower speed, air being admitted slowly from the main through the restricted orifice, reservoir and valve to the front end of the piston. It is necessary that there should be some cushioning on the return stroke, and this is provided for by making the piston cover the exhaust port

ELECTRO-PNEUMATIC DECKING PLANT FOR COLLIERY SHAFTS.

CONSTRUCTED BY THE WESTINGHOUSE BRAKE AND SAXBY SIGNAL COMPANY, LIMITED, ENGINEERS, LONDON.







before it reaches the back head. This port arrangement is shown in Fig. 41.

Another feature which is utilised in the underground gear, but not in that at the pit-head, is illustrated in detail in Figs. 53 to 57, annexed. This is an electro-pneumatic scotch block which is employed as a stop to locate the tubs which are being run into position ready for the next loading of the cage. They are indicated at 14 and 15, in Fig. 40. The details of the arrangement will be quite clear from Figs. 53 to 57, from which it will be seen the block is moved into position on to the line by a helical spring and that the compressed air motor works in opposition to this spring and compresses it when the block is moved out of the way just before ramming. The block is moved when the indications are given that the cage is in line and that the gates are open, while the operation of the block itself establishes a contact which allows the ram to come forward. The contact box operated by the operation of the block is attached by a link to the rocking arm, to be seen to the left of Fig. 53. The whole arrangement is indicated very clearly in Figs. 58 and 59. These figures do not relate to the Thurcroft installation, and in detail the lay-out is not identical with that at Thurcroft, but in principle the operation is the same.

A further feature of Fig. 40 to which reference may be made, is the bell-push shutter arrangement indicated at the bottom of the figure. This is introduced as an additional safeguard to prevent the signal for winding being given before the cage is loaded, the rams clear and the gates closed. It will be understood that this underground gear is not interlocked in any way with the pit-head gear, although we imagine there would be no electrical or mechanical difficulty in doing this. When the underground gear has operated and all is ready for the next wind, the man in charge gives a bell signal to the banksman, who, in turn, signals by bell to the engineman. To prevent the operation of the bell push before all is ready underground a small shutter is arranged which falls in front of the bell push. This is lifted when all is clear, and its operation makes it impossible for the wind signal to be transmitted to the banksman too soon.

Other features of Fig. 40 will be followed from the table which accompanies it and from its general resemblance to Fig. 4. The method of working is, of course, to line up six loaded tubs in sets of three against the scotch blocks on the leading-in rails to the two decks. When the cage arrives with six empty tubs, the gates open, the scotch blocks are removed and the loaded tubs are pushed into place on the cage, displacing the empties, which are pushed out on to the leading-away rails. Axle counters, indicated at 1 and 2, ensure that six axles pass out of each deck of the cage. As soon as the ram is clear of the cage, the gates close and all is clear for the next wind. Any remarks made in the first part of this description relative to safety and time and labour saving introduced by this electro-pneumatic gear apply equally, of course, to the underground installation as to that at the pit head. The question of time we have already referred to in detail. An 8-second stop has now been obtained at the pit top, and 6 seconds is very probable in the near future. Anything faster will necessitate too heavy wear on tubs and gear, owing to the high acceleration and deceleration. It should be borne in mind that these figures are for decking a wide cage with three tubs per deck, which means over 16 ft. stroke on the rams. Decking speeds, where there are only two tubs per deck, are higher still, as in such cases the ram stroke is usually only about 11 ft.

On the question of labour-saving it is not possible to say anything more striking than that it is anticipated the total cost of the electro-pneumatic installation will be paid for by wage savings in eighteen months. This is a very remarkable tribute to the value of the gear. It is mainly in the heavy work of moving the loaded tubs on to and from the cage that the saving is obtained. The work is heavy, and the conditions when it is carried out by hand are such that it is difficult for men to operate to good advantage. Saving in labour is, of course, a main feature, but the increased safety which the interlocking provides is really of equal importance, although much harder to estimate accurately in money values per annum.

THE INSTITUTION OF MECHANICAL ENGINEERS.

PRODUCER GAS POWER PLANT.

THE paper on "Some Observations on a Producer Gas Power Plant," by Messrs. H. S. Denny, C.B.E., and N. V. S. Knibbs, B.Sc., held over from the London meeting of the Institution of Mechanical Engineers of January 20, was read on Friday last, the 3rd inst., at Storey's Gate, Westminster, the president, Captain H. Riall Sankey, C.B., C.B.E., R.E. (retired), occupying the chair during the first part of the proceedings. The paper had already been read before the Manchester Section of the Institution on the 26th ult., and a report of these proceedings appeared on page 142 of our issue of last week. We commenced to reprint the paper in our columns on page 119 of our issue of January 27, and continuing it on page 152 of our last issue, conclude it in our current number (page 184).

Mr. C. P. Taylor was the first speaker. In the paper, he said, the calorific value of the coal was stated without any indication of whether the coal was dry or wet, an indication essential for comparative purposes. It would be interesting to know why the heat quantities were expressed in Centigrade heat units, seeing especially that coal and gas values were given in British thermal units. Mixing of the units involved avoidable arithmetic. He would also like to know why the authors stated the calorific value of their gas saturated at 15 deg. C. instead of adopting the more usual method of calculating it on the dry gas at 10 deg. C. This, on the analysis stated in the paper, would make a difference of 9 British thermal units per cubic foot, which it was necessary to bear in mind when comparing the author's figures with those of other investigators. The authors referred to the results presented by Mr. Patchell to the Institution of Electrical Engineers, in 1920, as too good, but made no attempt to justify the statement. Mr. Patchell, in his paper, gave a generator efficiency of 91 per cent., engine efficiency of 26 per cent., producer efficiency 77·6 per cent., or an overall efficiency of 18·35 per cent. The authors' corresponding figures for the first three were 93 per cent., 24 per cent. and 58·2 per cent. There was an additional factor in their case of 79·2 per cent. referred to later, giving an overall efficiency of 10·30 per cent. Mr. Patchell's overall efficiency figure of 18·35 per cent. was worked out from a fuel consumption of 1·7 lbs. of coal per net kilowatt, with an allowance of 3·6 per cent. for auxiliaries, no allowance being made for the fact that the exhaust boilers produced more steam than was required for power purposes. The authors had stated that it would have been difficult to improve the lay-out or efficiency of their gas-engine equipment. He disagreed, regarding a guarantee of 10,000 B.Th.U. per brake horse-power as poor. Mr. Patchell, with Premier engines giving the same power per cylinder, obtained a consumption of less than 9,000 B.Th.U. on full load. He (Mr. Taylor) had recently tested similar engines, of rather smaller cylinder capacity, and found a consumption of 8,200 B.Th.U.; these engines were ten years old, and, when new had given results as low as 7,500 B.Th.U. per brake horse-power hour. Clearly, the 26 per cent. efficiency on such engines was more than justified.

The maximum overload capacity of 5 per cent. was also bad, especially when the mean indicated pressure at full load was only 60 lb. per square inch. Why the engines failed to carry overload was not clearly stated, but was apparently due to pre-ignition. He thought the compression pressure of 148 lb. was too high for the gas which had to be used; on the Premier engines referred to the compression pressure was less than 135 lb., while Mr. Patchell had stated the compression pressure of his engines as only 120 lb.

Strictly speaking, the net efficiency of the authors' producer plant was 42·7 per cent., as the steam from the exhaust boilers should be debited to the producers and credited to the engines. The engine efficiencies did not, however, allow for this. On the basis that net efficiency of the producer plant was the relation between the lower value in the cold gas and the gross coal, it was, as given by the authors, 46 per cent. To connect this with the gross efficiency of the producers, namely, 58·2 per cent., an additional factor of 79·2 per cent. was introduced, representing the ratio between the coal gasified and the total coal used. This figure was essentially a commercial and not a scientific one. It would appear that the efficiency of the coal-fired boilers averaged about 45 per cent. If this and the efficiency of the exhaust boilers were raised to 70 per cent. a saving of 86 tons for the former boilers and a further saving of 33 tons of steam coal on account of the improved efficiency of the latter would have resulted. The total saving due to improved efficiency on both classes of boilers, namely, 119 tons of steam fuel, would result in the 79·2 factor being improved to 88 when the plant efficiency would increase to 11·45 per cent. There was, however, the question of the actual amount of steam to be supplied from external sources, in addition to that recovered from the saturation towers. The authors had stated that the total consumption was 2·44 lb. per pound of coal gasified, of which 0·85 was recovered in the towers, leaving 1·59 to be provided. He thought that that figure really related solely to the producers themselves, and had nothing to do with the cleaning plant. If the plant had required only 1·5 lb. of additional steam per pound gasified, as appeared to be practicable from Mr. Patchell's figures, the steam required would just about be obtainable from the exhaust heat boilers and the 79·2 factor would have been further raised to 100, with an overall efficiency of 13 per cent.

There still remained to be considered the question of the gross efficiency of the producers themselves, namely, 58·2 per cent., which appeared to be bad. Here the results obtained by Messrs. Bone and Wheeler given in a paper read before the Iron and Steel Institute in 1907, might usefully be considered. These authors had made a series of tests for the blast temperature ranging from 60 deg. C. to 80 deg. C. Extrapolating to the extent of the 85 deg. C., the CO_2 rose steadily with the saturation temperature, and the efficiency would, apparently, have been about 72 per cent. as between the lower value of the cold gas and the higher value of the coal. The results were worked out by means of the carbon balance. In so far as a direct comparison was justified, he thought that the producer efficiency in Mr. Patchell's plant was not quite so high as 77·6 per cent. He did not, however, think that any doubt was thereby cast on the overall figure; for as already pointed out, the 26 per cent. engine efficiency might well have been higher.

Generally speaking, the authors had used four separate methods of computing gas volumes. It was important, however, to notice that the carbon balance sheet method showed a production of 150,000 cub. ft. of gas per ton, or 15·4 per cent. higher than the figure of 130,000 cub. ft. chosen by the authors. It was interesting to note that utilising the carbon balance figure the authors' gross producer efficiency rose from 58·2 to 68·2, leaving only a comparatively small difference to be accounted for as between their results and those of Messrs. Patchell, and Bone and Wheeler. At the same time, of course, the engine efficiency would drop from 24 per cent. to 20·8 per cent.

In conclusion, Mr. Taylor desired to appeal to the Council of the Institution. There was a difficulty in comparing the figures of producer efficiency put forward by different investigators, due to the absence of a recognised standard method. He would therefore suggest that the Council should seriously consider the setting up of a small committee to make recommendations on the subject, possibly in conjunction with the Society of Chemical Industry.

The President intimated that he had spoken to the President-elect on the subject, and the matter of the formation of the suggested committee would be placed before the Council.

Mr. J. M. Hodgson said he was mainly interested in the question of gas measurement. He regarded the formula given in the paper for the Pitot tube as about 300 per cent. in error; the constant 66·2 should be 20·9. He attributed the error to the fact that the figure 10 was left in the denominator under the square root, whereas it should have been omitted. In the equation which followed, viz., volume $= V \times 0{\cdot}87 \times 12{\cdot}4 \times 60 \times 60 \times 22$, he thought the figure 22 should read 12, *i.e.*, 12 hours. He noticed that the gas had been measured by a Pitot tube, with an ordinary inclined manometer scaled in tenths and hundredths. With an ordinary piece of glass, assumed to be straight, considerable error might be introduced in the reading of fractions of one-tenth of an inch. With measurements of the order of those involved in the author's experiments it would be quite easy to make a 10 per cent. error in measuring with a Pitot tube not specially ground or calibrated against careful standards. In the manometer his firm had introduced for measuring these low heads the gauge tube was so made as to give equal spacing for the flow, and the manometer was calculated against precision manometers. The authors had suggested that the Venturi tube could not be used for measuring dirty gas, but he was aware of several working successfully with dirty gas. In the type he referred to the throat was made removable, and the tube could be cleaned out once a day or as frequently as necessary. In regard to Pitot tubes, the ordinary standard, known as the "National Physical," only measured the impact effect, but provision could also be made for measuring suction effect. Taking an ordinary round bar and drilling holes on the up-stream and down-stream sides with two pressure holes along the bar, a much more reliable reading would be obtained from the down-stream hole than from the up-stream hole. In recording apparatus of this kind it was very necessary to use large tubes; small ones were extremely sluggish in coming to zero; big holes were also necessary.

In order to obtain a good shadow effect a circular shield was placed between the up and down stream apertures of the Pitot tube, causing the flow to be spread as it passed the Pitot tube. This resulted in a considerable suction effect with one hole as well as an impact effect with the other. The tubes were ¾-in., quite big, so as to prevent clogging.

Mr. A. H. Lymn said he agreed with the authors' observation that the plant stood condemned by reason of its age, involving principles of obsolete practice and much time-worn material. He also wished to emphasise the point that in addition to the fact that the plant was 15 years old, it was designed to make sulphate of ammonia at £12 a ton, with fuel at 3*s* 9*d*., acid at 25*s*. and labour at 4*s*. per shift. The gas was entirely a by-product, and was to be used in very inefficient boilers belonging to the colliery or burnt to waste. Thermal efficiency had been deliberately neglected in the design. He had himself had much to do with the design, and had spent considerable time to see how far the plant could be cheapened without reducing its value as a sulphate of ammonia factory. The authors had given the gross hot gas value and gross heat entering the producers as about 81 per cent. and the efficiency—perhaps too low—of the whole plant as 42·7 per cent., half the heat units were lost in the plant. The authors had pointed out that the producer efficiency was low compared with text book or catalogue figures. The producer efficiency given by the authors was not a bad efficiency taken as purely producer efficiency. He thought it strange, however, in the case of a plant of this kind that the authors should have chosen to give a paper on efficiencies. The plant was in poor condition at the time of the test; there were leakage losses and large radiation losses, and bad labour. It was not even representative of the old Mond plant. The inference from the paper was that the Mond plant was inefficient, and there was no suggestion that it had been superseded by an improved Mond process. There were two more recent developments of the old Mond process, with one of which his name was associated. Even this had now been superseded. It might interest members to hear the result of three months operation of a modern plant, the figures being:—

Gas analysis—	Per Cent.
Carbonic acid	8
Carbonic oxide...	21 to 22
Hydrogen	20 to 21
Marsh gas	5 to 5·5
Nitrogen...	The difference

The net calorific value was 180 B.Th.U. per cubic ft.; gas yield per ton of fuel, 115,000 cub. ft. to 120,000 cub. ft.; ammonium sulphate yield, 90 lb. to 100 lb.; yield of tar, 15 gallons to 24 gallons per

ton of fuel; steam, 0·9 ton to 1 ton per ton of fuel—all of which would, of course, be required with a complete plant. The thermal efficiency of the plant, excluding tar, was 80 per cent., and including tar 90 per cent., while the gasification rate was 10 per cent. to 20 per cent. above normal. The gas composition given approached that of a hot gas producer. The authors had referred to the point that too much hydrogen was not good for the machine. Success had been achieved, in the new development, in producing a tar of low temperature quality containing a large amount of low boiling fractions. The gas leaving the producer had practically no dust, and the ammonia could also be recovered as liquor. In addition, the capital cost was reduced by about 40 per cent.

He considered that the efficiency of a plant should be based either on net heat units in the coal and net heat units in the gas, or on gross units in each. In conclusion he supported the suggestion to form a committee of the Institution to investigate the subject of standard tests, and thought the measurement of large volumes of gas might also form the subject of the committee's investigations.

At this point the President relinquished the chair to Dr. H. S. Hele-Shaw.

Mr. Harald Nielsen said the authors had submitted results obtained from a battery of gas producers capable of gasifying 140 tons of coal per day at an efficiency of not more than 45 per cent. instead of at least 75 per cent., as with a modern plant. The avoidable loss corresponded to a net waste of 13,000 tons per annum, or, in cash, 15,000*l*. The coal waste due to radiation and convection losses from the producers amounted to 18·5 per cent.; in ordinary modern practice this should not exceed 2 per cent. The difference or preventible loss represented 7,200 lb. of coal—in cash, 8,300*l*. per annum. The cost of re-lining and re-insulating the producers would not, perhaps, be more than 6,000*l*. He had tried to work out the evaporation ratio of water to coal in the Lancashire boilers. Making due allowance for steam recovery and exhaust boiler steam, he found that the Lancashire boilers were called upon to deliver 1·15 tons of steam per ton of coal gasified in the producers, to do which they consumed 0·265 ton of coal. The ratio of evaporation was therefore 4·3. He thought most engineers would agree that that figure ought really to be about 6·5 to 7. The net avoidable loss in this connection was about 40 per cent., corresponding to about 4,800 tons of coal per annum. Perhaps the boilers were all in the open air, all the joints blowing, and the greater part of the insulation was missing. He thought it was impossible to draw general conclusions as to the merits of gasification and ammonia recovery from an economical point of view, from a plant which should long ago have been on the scrap heap.

Mr. E. R. Dolby said the question of gas measurement was vital to the conclusions reached by the authors. In connection with measurement by the Pitot tube method of ducts 4 ft. diameter, as described in the paper, the standard practice would be to take four or six readings at specified distances on both the horizontal and vertical diameters. From the pressures thus obtained the velocities would be deduced and their average taken. The authors had used for the purpose of measuring their pressures an inclined manometer, presumably of the single liquid type. He thought that even with the use of a vernier such an apparatus was far from sufficiently accurate; the curve of the meniscus rendered it very difficult to read accurately. It appeared that the Pitot tube was placed in the centre of the duct, and the authors explained that they had used the standard procedure and deduced a constant of 0·87. He was interested in that figure, which compared with the constant for heated air, usually taken as 0·91. He had also found that the maximum velocity did not always occur at the centre of the duct, but usually a little higher. At the National Physical Laboratory a two-liquid Chattock gauge was used for this class of work, for which an accuracy of about $\frac{1}{1,000}$ in. was claimed. At the Illinois University experiments with warm air furnaces had been carried on for the last three or four years continuously. For these the inclined manometer and the Chattock gauge had been discarded, and a new type of two-liquid gauge, known as the Wahlen gauge, was employed. For this they claimed an accuracy of $\frac{1}{10,000}$ in. Anyone wishing to have particulars of this gauge could find them in the Illinois University Bulletins Nos. 112 and 120. Recently, at the National Physical Laboratory, he had been shown a new type of electric wire manometer, which he regarded as very promising.

Dr. A. P. Thurston said that, at the National Physical Laboratory, after many years' experimenting, they had come to the conclusion that the most accurate method of determining the amount of gas passing through a tube was by means of a small hole in the side, combined with a very accurate manometer. For comparatively rough measurements a useful instrument was the micro-manometer invented by Mr. Roberts. The Chattock gauge or the electrical instrument invented by Professor Morris, referred to by Mr. Dolby, could also be used. The principle of the latter was the variation of the resistance of a wire according to temperature, and it was so extremely sensitive that, placed at one end of a room, it would give a jump in response to a wave of the hand by a person at the other end of that room. It could be adjusted in any position, and it read accurately when he had altered the inclination to the extent of 45 deg. By carefully graduating the channel or tube over the whole section, and then deciding the factor, it was a very simple matter to measure velocities as low as half a foot per second up to comparatively high velocities. For ordinary work, however, the micro-manometer referred to placed in the hole in the tube was difficult to beat. The National Physical Laboratory had tried Pitot tubes, but had found the hole in the tube, combined with the micro-manometer, more accurate.

Mr. Thomas Rigby said that the results given showed the plant to have been badly worked or badly arranged; in ordinary experience much better results were obtained. The quality of the gas produced was apparently not more than 35 per cent. to 36 per cent. combustible. It was common, with recovery plants working with 85 deg. C. of blast saturation, to get 95 lb. of sulphate of ammonia per ton gasified, with 1·4 per cent. nitrogen in the coal. From the authors' figures it seemed that the producer was overworked in the attempt to gasify one ton of coal per hour in a 10 ft. 6 in. diameter producer. Under ammonia recovery conditions, a producer diameter of 11 ft. 6 in. was required for the efficient gasification of one ton of fuel per hour. Fig. 1 in the paper showed an ammonia line which went up and down continually, which was proof that the producers were being badly worked. The National engines apparently would not pull an overload, but his experience of the same type of engine, given gas of 40 per cent. combustible, showed that the engine did pull the overload, even under ammonia recovery conditions. He did not consider it quite fair to base opinions and reasoning on a war-time job, and the poorer working to be expected under such conditions. He agreed with the authors in crediting to the gas engines the steam generated in exhaust steam boilers, as if it were not used for gas producers it could be used for other purposes, and might indeed generate steam power to supplement the output of the station.

With regard to Messrs. Bone and Wheeler's paper, it should be remembered that Professor Bone's experiments were chiefly concerned with the use of the gas in a steel and iron works, but the yields he obtained when using various quantities of steam through the gas producers were applicable to power practice. These figures showed that, with the same producer, the same coal, and a 7 ft. depth of fire, when working with a blast saturation of 60 deg. C. and 0·45 ton of steam per ton of coal gasified, 138,250 cubic feet, calculated at 0 deg. C. N.T.P., were produced, having a calorific value of 185·6 gross and a net value of 173 B.Th.U. per cubic foot at 0 deg. C. When using a blast saturation of 80 deg. C. and 1·55 ton of steam per ton of fuel, with the same coal, the value of the quality of the gas went down to 169 B.Th.U. per cubic foot higher scale, and 154·3 B.Th.U. lower scale. At the same time the quantity of the gas available per ton of fuel had gone up to 147,500 cubic feet per ton. In his opinion, had experiments also been conducted at 85 deg. C., very similar results would have been obtained as regards overall and gross gas efficiency.

The more steam carried, within limits, the lower the heat value of the gas, but the larger the heat volume per ton. The value of the fuel used in the case of this plant was 13,880 B.Th.U. per pound higher scale and 13,340 B.Th.U. per pound lower scale. It was interesting to note how the overall efficiencies worked out on Professor Bone's figures. Taking the gross value of the fuel gasified and the lower or net value of the gas produced, with the blast saturated at 60 deg. C., the efficiency was 77 per cent., whereas in the case of gas produced with the blast saturated at 80 deg. C. the efficiency was 72·2 per cent., or a reduction, owing to the latent heat of the burnt hydrogen, of 4·8 per cent. heat value. Taking the net heat value of the fuel and the net value of the gas, the corresponding efficiencies worked out at 80 per cent. and 76·7 per cent., which were very different figures from anything shown by the authors. The figures showed also that, given a producer properly designed and properly worked, the overall heat efficiency was not greatly different with varying proportions of steam. These figures did not, of course, allow for the cost of the steam added to the blast, which at present was the weak point of the Mond process, as so much auxiliary steam had to be raised in auxiliary boilers. There was sufficient heat leaving the gas producers and superheaters in a Mond plant (sensible and latent heat) to furnish more than the whole of the heat required for the steam, even with 85 deg. C. saturation, if efficiently utilised. This, however, was not done in the present system of Mond towers, a large proportion of the heat passing away with the gas leaving the gas cooling tower. The point was well illustrated in Figs. 5 and 6 in the paper, which showed that from 17 per cent. to 19 per cent. of the heat was lost in sensible and latent heat during the gas cooling. This was the reason that such expensive cooling plants were required to condense the steam and cool the gas. He thought the whole of the steam required for starting the blast under ammonia conditions and also for evaporating the sulphate of ammonia liquor could be produced practically from the heat content in the gases before leaving the superheaters. If that were practicable it would cut out a lot of plant for cooling and a lot of auxiliary boilers, and the economic result would be that it would be possible to gasify coal with a net efficiency of from 70 per cent. to 75 per cent. cold gas efficiency, at the same time recovering ammonia and tar in the process as by-products.

Mr. W. H. Patchell remarked that he had been pleased to see the authors' paper, because, in spite of its mistakes, it gave an opportunity to discuss measurements and also showed what not to do. The authors of the paper under discussion were condemnatory of the old Mond plant, but he thought a system should not be condemned on the results of experiments with an obsolete plant. His own paper had been based on results taken in ordinary commercial work, neither opportunity nor staff being available for elaborate tests, whereas the authors had apparently very many assistants. In gas-producer testing there were two important things to consider, the coal going in and the gas coming out. In the authors' experiments the coal weighing left much to be desired; they used an Avery weigher and had trucks with storage hoppers of 700 tons capacity. It seemed to him that there would be a good deal of guessing when measuring with such means. The test was for a week, and part of the test was on boilers which any mechanical engineer would have been ashamed to speak of—old Cornish boilers with 50 per cent. efficiency. In the exhaust boiler experiments, he was much interested. Mr. Taylor gave steam figures in kilowatt-hours, whereas the authors used brake horse-power. The latter had set out water evaporation in the exhaust boilers as 1,220 lb. per hour for the 750 b.h.p. engines, or 1·93 lb. of water per brake horse power from and at 212 deg. F. He did not follow the figures. Dividing 1,220 by 750 gave 1·63. There appeared to be discrepancies with certain other figures. If—turning to another point—enough oil were put into a gas engine it could be

run as a Diesel. The authors gave cylinder oil consumption, but presumably they had no lubricating oil, which in the case of some gas engines was a very important item.

If the whole of his (Mr. Patchell's) gas plant had been giving gas, he would not have required any extra steam; his engines made on the exhaust more steam than was wanted with ammonia recovery conditions. An important part of the paper was that relating to the volume of gas measurements. In addition to the methods of determination used he regretted that the authors had not tried the orifice method and had not said anything about the Venturi method, mentioned by Mr. Hodgson. The orifice method appealed to him as simple, because the flanges in an ordinary steam or air pipe could be opened and a plate with a properly gauged orifice dropped in. It was then possible to get the difference in pressure due to friction through the hole. One difficulty was in getting accurate gauges. Several sorts had been mentioned. A method applicable to long pipes might be hopeless with short ones. The authors had given an average figure, for the four different methods of gas measurement, of 131,600 cub. ft. of gas per ton of coal, but he worked out the average as 133,875 cub. ft. He hoped that Mr. Hodgson would expand his remarks by saying something about the orifice method of measuring. That method had lately been adopted in a furnace plant, according to an abstract in the *Iron and Coal Trades Review*, of a paper read before the Institute of Mining and Metallurgy on May 20 last year. Referring to the wire grids invented by Professor Morris, the grid was put right across the pipe from which measurements were to be taken and air was blown across it, and the difference of the electrical resistances as between that grid and another grid, kept in the cold, were taken. He had seen this method used. Messrs. Metropolitan-Vickers of Manchester, had lately used it for measuring air discharged from a very large steam turbine, an account being given in their Journal. He did not think it would serve for gas, as the grid would get a film of tar or dirt on it which would upset the electrical resistance.

Alluding to his own paper, it had been suggested that the volume of gas produced had been overestimated. In this connection, he would explain that part of the quantity used was on engines which had been calibrated to one meter, while the rest was used on furnaces which were carefully checked and calibrated, and the figure given in his paper was an average of six months measurements; the last month gave 76, and there were two months which showed the figure of 79, while the average was 77·6. He had learnt from those who had since worked the plant that his figures were not overestimated. The capital cost of his plant did not compare with that of the authors' plant. He used 500-h.p. engines of the horizontal slow-speed type, and more would, of course, be paid for small units and slow speed than for heavy units and high speed. The slower-speed engines were erected in three different engine rooms under conditions over which the purchasers had little control, due to war time; labour and coal handling costs were also high. The tests were not show tests, but made merely to indicate what the plant was doing.

Mr. H. S. Denny, for himself and Mr. Knibbs, then replied to the discussion, and observed that nothing had occurred in the course of the discussion to which he believed that it would not be possible to present satisfactory answers. As to the criticism bearing on the age of the plant, they had at the outset of the paper frankly explained that the plant was old; but with the producer part of the plant there was little to complain of to-day. As regards some other parts, *i.e.*, pipe lines auxiliary plant, sulphate plant, &c., these were decidedly poor, and when stating that the plant stood condemned on those grounds alone he meant from the point of view of highest efficiency; he was not thinking of the scrap heap; he would not have wasted time in collecting records from a scrap heap. It had seemed to him that the plant afforded an excellent opportunity for testing the principles of the Mond gas system. His first view of the plant showed him that he would not be able to make any statement in relation to it from the point of view of modern efficiency, but he did see the foundations for a sound investigation of principle, and he did not think it could be said that the plant was so poor that the evidence and data collected would be of no use in judging the principle; on the contrary, he regarded these data as quite important. The very excellent figures submitted by Mr. Lymn marked an extraordinary rapid development in the use of Mond gas, and he could only hope that Mr. Lymn's figures were right; he knew of no results which would compare with them.

Some one had referred to the poor boiler efficiencies. Mr. Brownlie, who had investigated boiler efficiencies for 250 picked installations, had not found an efficiency greatly higher than in the old plant under discussion. There were many plants to-day, considered quite good by their owners, which had efficiencies well under 50 per cent. Even Mr. Lymn's efficiency figure of 84·5 per cent. would not make a great difference to the authors' figures. Mr. Patchell had stated that he had been able to do without steam raised in an auxiliary boiler plant; that was important. On going into Mr. Humphrey's figures it was found that he was getting a great deal of heat from somewhere, but not from the exhaust of the gas engines. The authors put it into coal, and the amount of coal was considerable. He would accept Mr. Lymn's statement that it was possible to get all the steam required from the exhaust boilers, although he had no such case himself; he would have to take Mr. Lymn's figures for it.

Dr. Hele Shaw then announced that an informal meeting of the Institution would take place to-day at 7 p.m., the topic being "Water Power," introduced by Mr. R. B. Stewart. There would be an extraordinary general meeting on Friday, February 17, at 5.50 p.m., to confirm the articles passed on January 20, followed by the annual general meeting on the same day at 6 p.m., at which meeting the annual report would be presented. A paper on "Electric Welding applied to Steel Construction, with Special Reference to Ships," by Mr. A. T. Wall, would be read and discussed.

The proceedings then closed.

5-TON STEAM WAGON WITH UNIFLOW ENGINE.

The latest pattern of steam wagon developed by Messrs. Atkinson and Co., of Frenchwood Works, Preston, has many special features and forms a remarkably interesting vehicle. The 5-ton tipping model which we illustrate on this and the next pages, and on Plate VI, is a characteristic example of the firm's latest practice and embodies the Atkinson uniflow engine and the auxiliary tipping engine which they have introduced. The vehicle is constructed to carry a maximum load of 5 tons up a gradient of 1 in 8 and to run at 8 miles an hour on the level. The end tipping body is 12½ ft. long by 7 ft. wide, and the tipping engine can lift the body and bring it back into position in about 2 minutes. Drawing a trailer the wagon can handle a total load of 9 tons at a speed of 5 miles an hour.

5-TON STEAM WAGON WITH UNIFLOW ENGINE.

CONSTRUCTED BY MESSRS. ATKINSON AND CO., ENGINEERS, PRESTON.

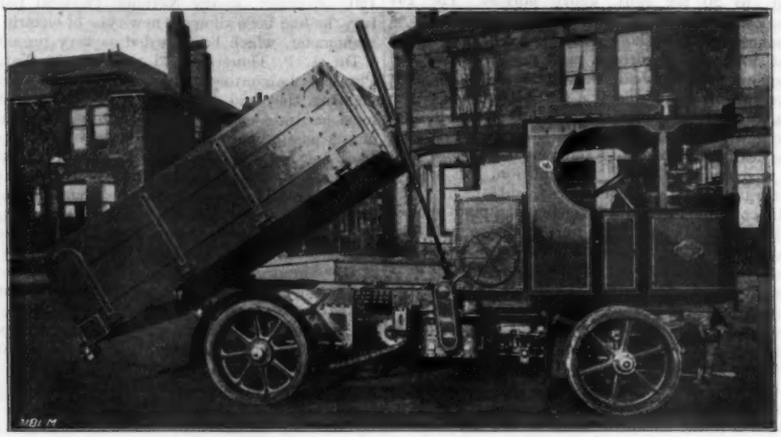


Fig. 1.

A general view of the vehicle is given in Fig. 1 on this page, while a side elevation is given in Fig. 2, on Plate VI. The engine is fixed below the chassis and drives on to the back axle by a chain transmission which can be seen in Fig. 1, and is indicated by a broken line in Fig. 2. Before referring to the details of the engine, which may be looked upon as the special feature of the vehicle, we may, however, make some reference to the chassis and axle arrangements. The chassis requires little comment. It is built up of British standard rolled steel sections with cross-bracing, gussets and knees. The front axle and steering arrangements are illustrated in Figs. 3 and 4, on Plate VI. The axle is of solid-drawn steel tube with cast steel brackets shrunk on the ends. The pivots and journals are steel forgings, and the pivots work in adjustable bronze bearings. The wheels are made from cast steel from an electric furnace and are fitted with single rubber tyres. The steering arrangements will be quite clear from the figures. The steering screw rotates in a bronze nut and is well protected from dust. It works in an oil bath. The drag-link ends are spherical and are adjustable.

The rear axle is illustrated in Figs. 5 and 6. As will be clear the transmission arrangement is very simple. The axle carries a sprocket which is driven by a 2½-in. pitch roller chain from the sprocket on the engine crankshaft, and the differential pinions are carried in the back axle sprocket. As will be seen the axle is flanged out to carry one of the crown wheels of the differential, the other being carried by the flange of the sleeve of the floating wheel. The differential gear is enclosed in a dust-tight casing and the axle journals are lubricated by pads held up by springs in the axle boxes. Steel radius rods are fitted to take the back-axle thrust. Brake drums are bolted to each road wheel and expanding brakes of the type shown in Fig. 6 are fitted. They are operated by pedal and details of the compensating gear are given in Figs. 7 and 8. Additional braking power when necessary may be obtained by reversing the engine.

Turning now to the engine of which a cross-section and plan are given in Figs. 9 and 10 and a general view showing the unit in place on the chassis in Fig. 11, it may first be pointed out that the construction is very simple. There are, of course, no exhaust valves, and the admission valves consist of steel balls which it is stated never require grinding. There is only one camshaft, the valves for the two ends of the cylinders being actuated from a common shaft and cam as clearly shown in Figs. 9 and 10. This shaft is driven by spur gearing from the crankshaft as can be seen in Fig. 10. Control of the engine is carried out by moving the camshaft endwise and three points of cut off are given by the cams, corresponding to 0·25, 0·5 and 0·75 of the stroke for forward running and 0·75 of the stroke for reverse. A neutral cam is also provided to open the valves sufficiently for warming up. As a steam wagon has frequently to run very slowly, large relief valves are fitted in the pistons to relieve the compression due to the uniflow system. As will be seen

FIVE-TON STEAM TIPPING WAGON FIT

CONSTRUCTED BY MESSRS. ATKIN AND C

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Fig. 2.

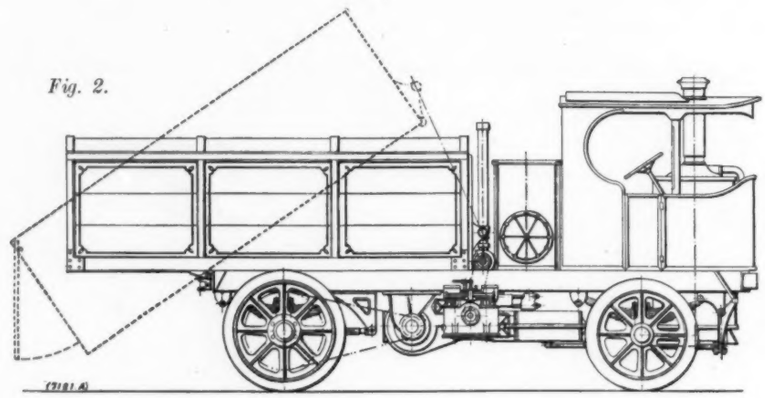


Fig. 3.

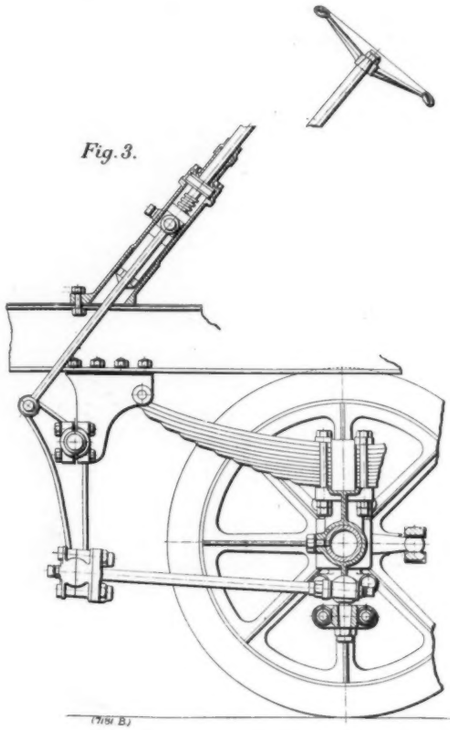


Fig. 9.

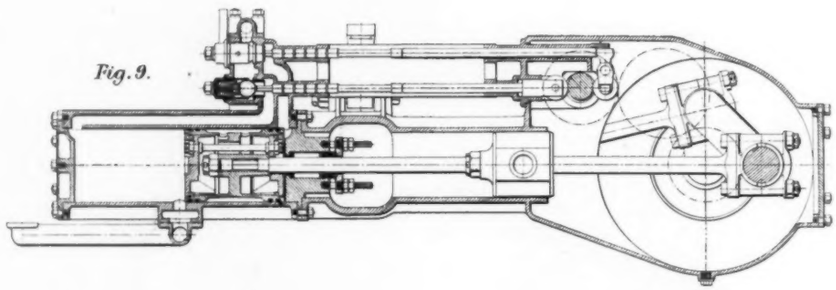


Fig. 10.

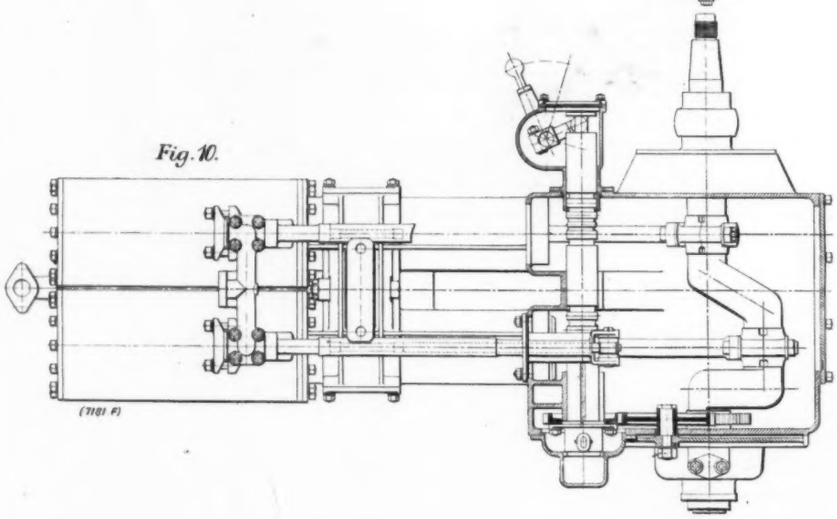
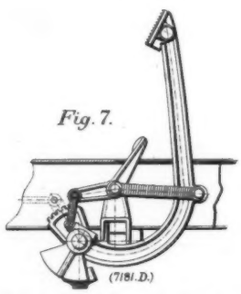


Fig. 7.



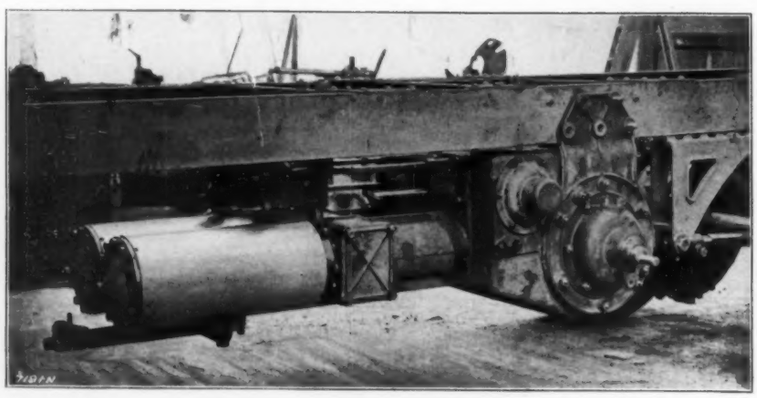


FIG. 11. ENGINE IN POSITION ON CHASSIS.

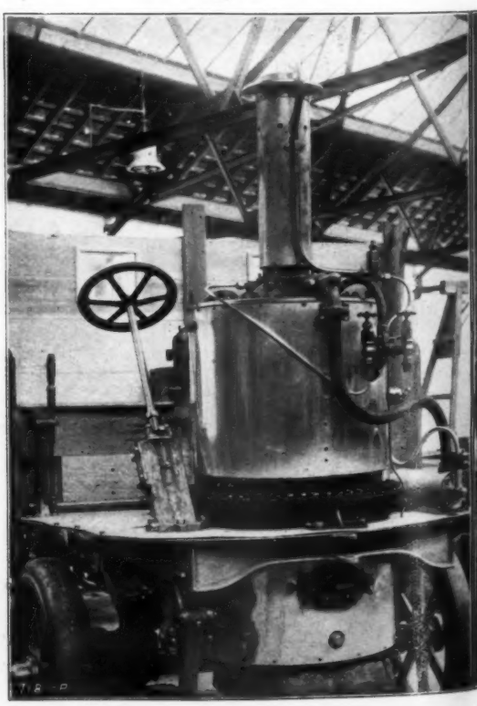


FIG. 12. BOILER ASSEMBLED IN CHASSIS.

GON FITTED WITH UNIFLOW ENGINE.

ATKINS AND CO., ENGINEERS, PRESTON.

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Fig.

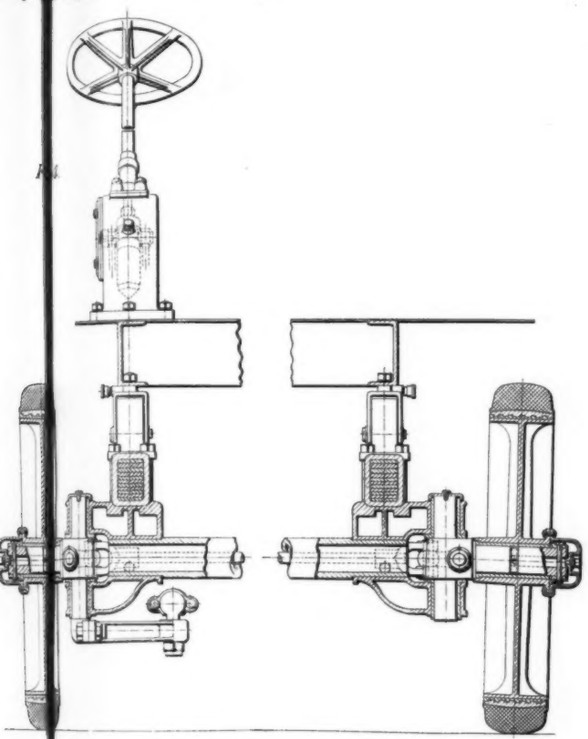


Fig.8.

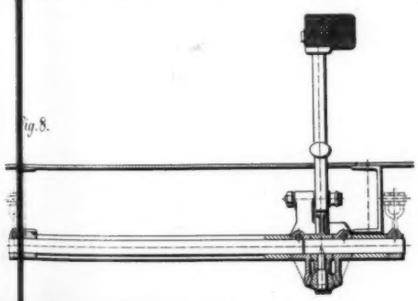
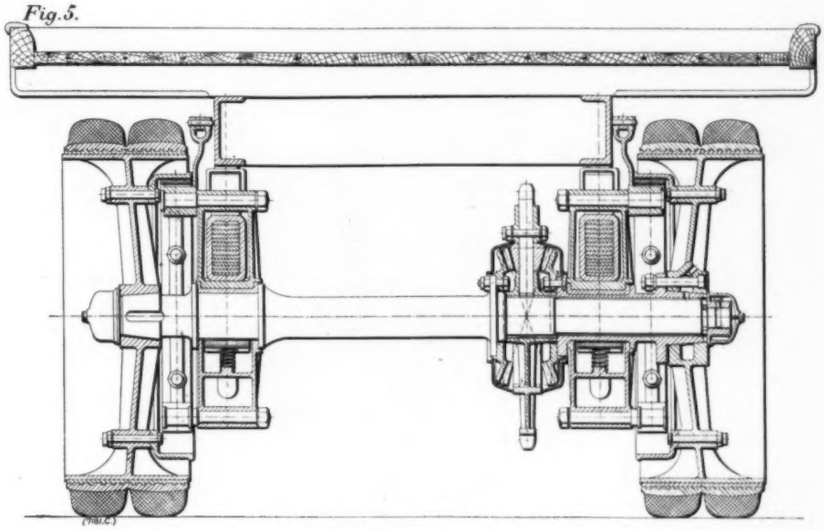


Fig.5.



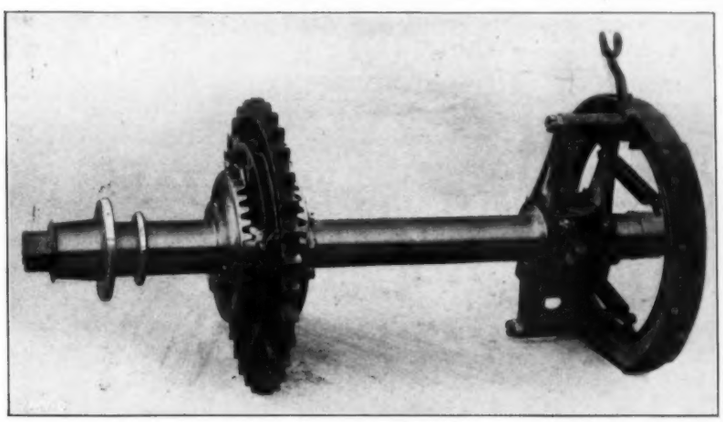


FIG. 6. REAR AXLE.

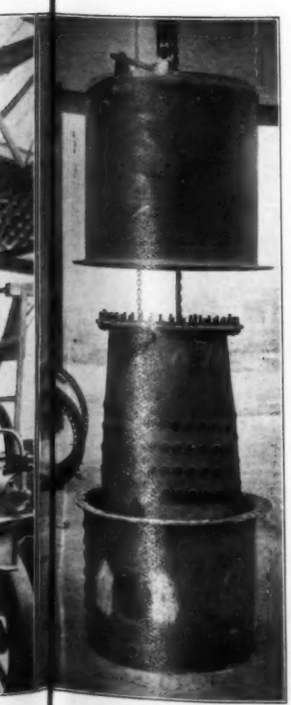


FIG. 13. MAIN PARTS OF BOILER.

Fig. 14.

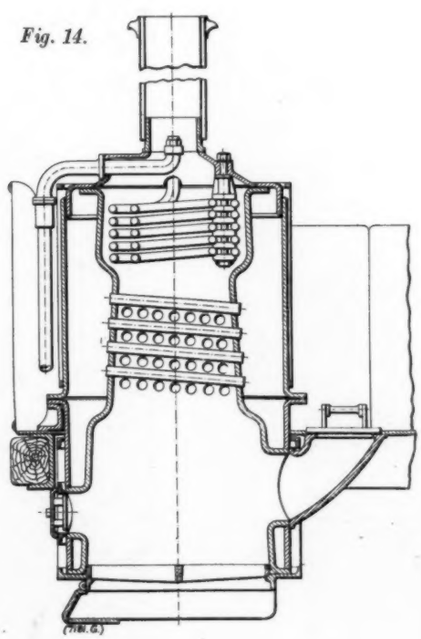


Fig. 15.

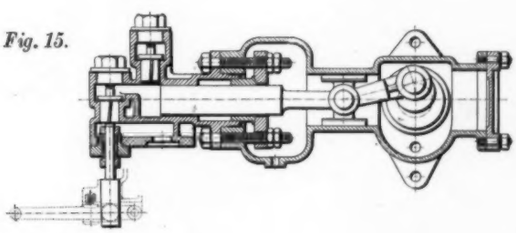


Fig. 16.

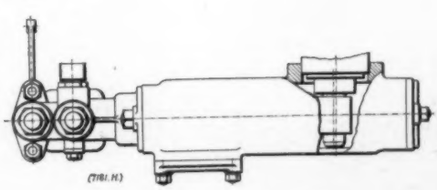
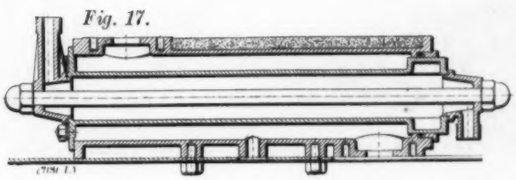


Fig. 17.



5-TON STEAM WAGON WITH UNIFLOW ENGINE.

CONSTRUCTED BY MESSRS. ATKINSON AND CO., ENGINEERS, PRESTON.

Fig. 18.

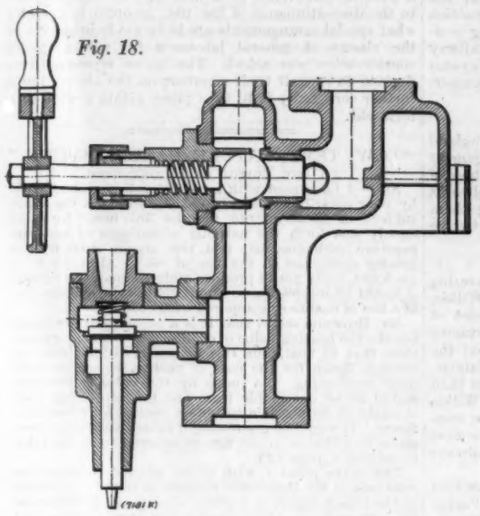


Fig. 19.

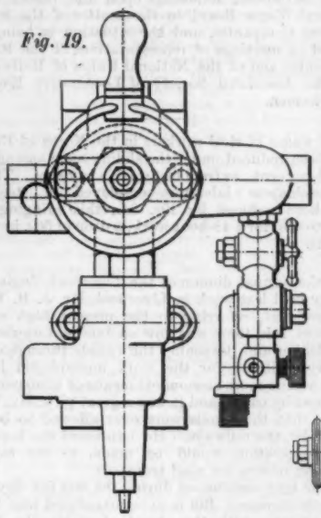


Fig. 20.

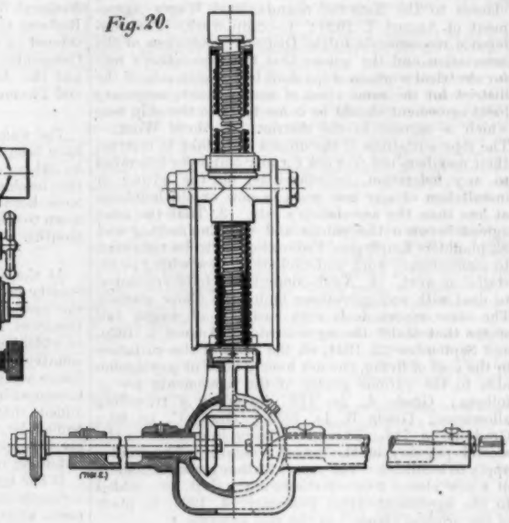


Fig. 21.

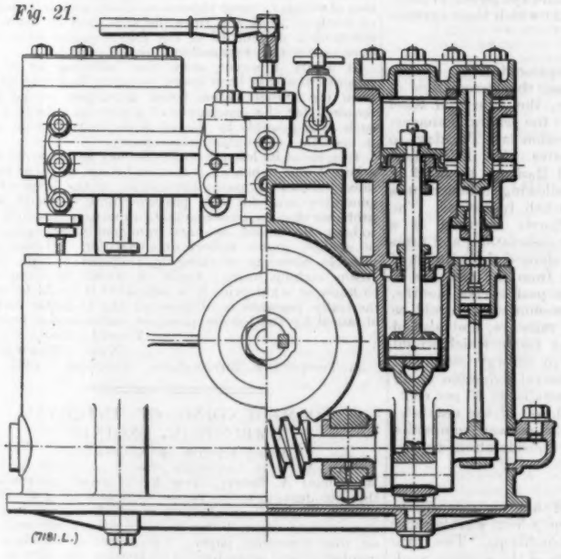


Fig. 22.

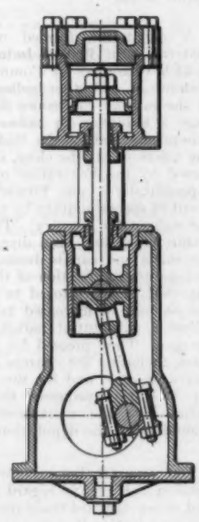
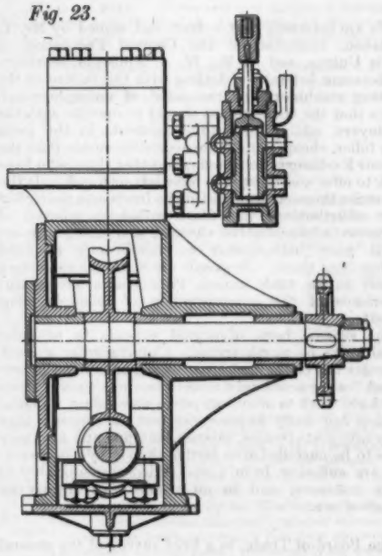


Fig. 23.



there are two cylinders. These are of 6¾ in. diameter and 10 in. stroke. The engine runs at 200 r.p.m. when the wagon is travelling at 8 miles an hour. In connection with this uniflow engine it may be said that Messrs. Atkinson first employed the type in 1918 in connection with Colonial work, in which loads of 12 tons had to be transported over bad roads, and its success was such that the firm is now fitting it as an alternative in their standard 6-ton flat-deck wagons and 5-ton tippers. The wagon with which we are concerned in this description is still built with the original Atkinson engine, but the enhanced simplicity of the uniflow model which we describe is likely to recommend it to many users.

The boiler is shown in position on the vehicle in Fig. 12, on Plate VI, while Figs. 13 and 14 respectively show it partly disassembled and in cross-section. The working pressure is 230 lb. per square inch, the heating surface is 55 sq. ft., and the grate area 3·3 sq. ft. As will be clear from Figs. 13 and 14, the boiler is virtually made in two pieces, a fire-box with water tubes and an outer shell. Practically no rivets are used in the construction, and the fire-box is welded to the lower part of the outer shell. Welding is also used at the firehole and clinkering hole. No screwed tubes are used, all being expanded. To clean the boiler it is only necessary to lift off the top portion when the superheater and cross-tubes are all exposed. To obtain access to the water space the circumferential joints in the outer shell and the joint at the top of the fire-box have to be broken. These are flanged joints in which graphite-covered asbestos rings are used. The rings stand well and may be used many times. As will be clear from Fig. 14, the boiler is fired from a chute on the level of the footplate. There is a clinkering door in front which is in an easily accessible position, as will be clear from Fig. 12. The superheater is a solid-drawn steel coil and is large enough to add about 100 deg. F. superheat to the steam.

A feed pump is fitted in connection with the boiler. This is illustrated in Figs. 15 and 16, on Plate VI, from which the construction will be under tood without detail reference. The pump is driven by a crank-pin on the end of the main engine crankshaft. The pump is, of course, always working when the wagon is running, and in the event of too much water being pumped into the boiler the driver stops the flow by raising the suction valve with a steel cord which is connected to a lever in the cab. The result is that the water is simply pumped backwards and forwards in the suction pipe. The feed passes through a feed heater on its way to the boiler. The heater is illustrated in Fig. 17. The water passes through the inner tube and the exhaust through the outer. The design of the heater permits of easy cleaning inside and out. The boiler is fitted with the usual gauges, injector, safety and blow-off valves and filling and wash-out plugs. These fittings require no detailed reference. Attention may, however, be directed to the stop valve which is illustrated in Figs. 18 and 19, on this page. The stop valve proper is of the steel ball type similar to that used in the engine, but in addition the fitting contains a release valve which is operated by a foot lever when a sudden stop is necessary, and also when the engine is reversed and running down hill and acting as an air compressor brake.

The main items in connection with the tipping gear of the wagon are illustrated in Figs. 20 to 23 above. The telescopic lifting screw is shown in Fig. 20 and the tipping engine in Figs. 21 to 23. The engine, as can be seen from Figs. 1 and 2, is carried at the side of the chassis and drives the cross-shaft of the lifting gear through a chain. The chain guard can clearly be seen in Fig. 1, while the chain sprockets on the lifting gear and engine cross-shaft are shown at the left hand side of Fig. 20 and the right-hand side of Fig. 23. The tipping engine itself requires no detailed comment, as its construction is clearly indicated in Figs. 21 to 23. The crankshaft, as will be seen, drives by worm on to a cross-shaft carrying the sprocket. The engine runs at 900 r.p.m., and can lift the body and return it to its initial position in about 2 minutes. In concluding this description of a very interesting vehicle it should be said that the wagon has an overall length of 21 ft. and an overall width of 7 ft. 5 in. The wheel base is 10 ft. 6 in., the rear wheel gauge 5 ft., and the front wheel gauge 5 ft. 5 in. The water tank has a capacity of 170 gallons.

INDUSTRIAL NOTES.

A CONFERENCE was held on January 26 between the National Federated Electrical Association and the Electrical Trades Union, when, according to a report we have received, it was resolved to add the following clauses to the National Standardised Wages Agreement of August 7, 1920: 1.—Ship work.—The conference recommends to the District Committees of the association and the unions that the association's rate for electrical work on ships shall be the ship rate of the district for the same class of work; where necessary local agreement should be come to as to the ship rate which is current in the district. 2. Shore Work.—The representatives of the unions undertake to instruct their members not to work for any employer federated to any federation, or otherwise, on the wiring or installation of any new work in new or old buildings at less than the association's rate. 3. That the rates agreed between the unions and the Engineering and Shipbuilders Employers' Federation are to be restricted to maintenance work and exclude all new wiring or installation work. 4. A sub-committee is to be appointed to deal with any grievances under the above clauses. The same report deals with variation of wages, and states that under the agreements of August 7, 1920, and September 22, 1921, on the basis of the variation in the cost of living, the net hourly rates of pay applicable to the various grades of the agreements are as follows: Grade A, 2*s.* 1½*d.*, including a travelling allowance; Grade B, 1*s.* 10¾*d.*; Grade C, 1*s.* 9*d.*; Grade D, 1*s.* 7½*d.* These rates come into effect on the second pay-day in the present month. The grades apply to localities. The report further gives particulars of a new clause 3 on overtime, night shift, &c., added to the agreement dated February 24, 1921, in place of the original clause 3 in the said agreement.

We are informed that a draft Bill, signed by Mr. T. Mallalieu, chairman of the General Federation of Trade Unions, and by Mr. W. A. Appleton, secretary of the same federation, dealing with the failure of the existing machinery for the relief of unemployment, states that the trade unions should co-operate with the employers, adding that advertisements in the press offer fuller, cheaper and more accessible means than the Labour Exchanges for bringing together those who have work to offer and those who have labour to sell. If the industries themselves provided the funds and controlled their distribution, the State would be relieved of enormous administrative charges, and many persons would have inducements to mendicancy removed further from them. Proposals are made for conferring powers on the trade unions, these bodies having had experience of the administration of unemployment benefits.

The scheme here advocated appears to us most certainly to be worth trying. Unfortunately a great difficulty lies in the fact that "those who have labour to sell" are exceedingly more numerous than "those who have work to offer" at prices now ruling. Before matters can really improve, we fear the elements that enter into costs (wages, salaries, emoluments, &c.) may have to be curtailed even further than has yet occurred. We are suffering from costs added unreasonably in many instances, and in an erratic way during the period of war.

The Board of Trade, in a brief survey of the general industrial position, states that everyone is looking hopefully for the promised revival of trade, and there are faint signs that these hopes are likely to be fulfilled, but many uncertain factors remain. Raw material prices with few exceptions continue to fall, and further wage reductions have taken place in many industries, resulting in a lowering of the prices of manufactured goods, and enabling British makers to compete more effectively with their foreign rivals. The increased facilities provided by the new export credits scheme have been taken advantage of, and a considerable amount of trade has been done which would not otherwise have been possible. The proposed International Corporation for reviving trade on the Continent should hasten recovery, and if a satisfactory settlement of the reparations problem can be achieved, a great step will have been taken towards the establishment of conditions in which stable trade relations are again possible. Stability is the main essential, for as long as prices and costs remain unstable, buyers hold aloof and refuse to enter into long-period contracts. In regard to the iron and steel industry, it is added, improvement proceeds but slowly. Although costs have fallen substantially both in respect of wages and raw materials, the feeling that prices have not reached rock-bottom still prevails, and business is suffering in consequence.

The award of the National Wages Board in regard to the Scottish Railway Companies (see page 116 *ante*) has been considered at special delegate conferences, held in London, of the National Union of Railwaymen. After discussing the award in detail, the delegates, it is reported, decided to accept it. The English and Welsh Railway Companies have now submitted an application for alterations in rates of wages and hours of labour, following upon the report of the National Wages Board in the matter of the Scottish Railway Companies, and the situation is being considered at meetings of representatives of the Railway Companies and of the National Union of Railwaymen and the Associated Society of Locomotive Engineers and Firemen.

The wages of steel workers in the North of England have been reduced under the sliding scale arrangement by 33⅓ per cent., as from last week's pay-day. Those of the bricklayers' labourers employed in steelworks have been reduced by 10*s.* 8*d.*, this bringing them down to 48*s.* for a 48-hour week, a drop of 50*s.* in twelve months.

At the annual dinner of the Liverpool Engineering Society held last week in Liverpool, Mr. J. B. Wilkie, the president, referring to the present high cost of transport, said there was now an excellent opportunity of widening and deepening the canals throughout the country, utilising for the work unemployed labour. There was no more economical means of transport than transport by canal, and it was a great pity, Mr. Wilkie added, that the canals were ever allowed to be controlled by the railways. He expressed the hope that every opposition would be made to the railways obtaining powers for road transport.

It has been announced during the last few days that a private members' Bill is to be introduced into Parliament shortly, with the object of giving the North-Western and Midland group of railways power to carry traffic by roads in the districts to which their systems afford access.

A deputation formed of representatives of the Federation of British Industries, the Association of British Chambers of Commerce, the Iron and Steel Federation, and other bodies met the general managers of the railway companies in London last Tuesday, to urge a reduction in railway rates. Mr. F. Tatlow, general manager of the Midland Railway, presided at the meeting. At the close, the following statement was issued by the Federation of British Industries. The representatives put forward figures acquired as a result of special inquiry by trade associations and firms throughout the country. They showed the amount of traffic which had been diverted from the railways to the roads and canals during the past twelve months, and gave an indication of the amount which could be expected to be restored to the railways, and also of the amount of increased railway traffic which would follow a substantial reduction in railway rates and charges. They pressed for a general reduction of all rates, including the charges for smalls, to 50 per cent. above pre-war, and for the abolition of the flat rate. Mr. F. Tatlow promised that the railway companies would give the most serious consideration to the arguments of the deputation.

The General Labour Council held a meeting in London last week in regard to the 8-hour working day and other standard trade union conditions. The trade unions maintain that an extension of the working week is not likely to help employers in reducing the cost of production. In this connection Mr. F. Bramley, the assistant secretary of the council, is reported to have stated that "by far the most important aspect of the question is in relation to other countries," adding that "this nation and the other nations represented at the Washington Conference were committed to an 8-hour day by article 2 of the Washington Conference, &c." In the ordinary run of work more can be produced in a long day than in a short one. This point needs absolutely no enlarging upon. But it is high time that British workmen should cease to be deceived by the nostrum of internationalism as far, at all events, as it relates to the 8-hour day, for we know for a fact, and British labour leaders if they do not know can most easily ascertain, that Continental workmen are always glad to increase their earnings by working longer hours. The alacrity they display in doing so has had for effect to lose this country many orders, to the profit of their own country, whose benefit they value much more than the maintenance of "a principle."

Representatives of the Engineering and Shipbuilding Trade Unions met on Tuesday, and held a conference on Wednesday with the Shipbuilding Employers' Federation in regard to the abolition of the 26*s.* 6*d.* weekly war bonus, to which we have referred in past issues. The Employers' Federation propose that 16*s.* 6*d.* of this bonus be discontinued on and from March 15; that within the next fortnight a further conference be held in order to consider as to the date from which the remaining 10*s.* shall be discontinued; that consideration be given at this same conference to the period of time to elapse before there can be any further general alteration in wages in the industry; a separate conference to be held with the unions, prior to the discontinuance of the 10*s.*, in order to consider what special arrangements are to be made in respect of the classes of general labourers for whom special consideration was asked. The union representatives decided to consult their members on the above, and a further conference is to take place within a week or a fortnight.

"LOW TEMPERATURE CARBONISATION."

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with great interest the able article by your contributor, Mr. David Brownlie, on the above subject in ENGINEERING for the 3rd inst. In it he clearly sets forth the national advantages of low-temperature carbonisation, and the urgent necessity for greater economies in the use of coal. Although it is, no doubt, early yet to produce truly comparative figures, it would be interesting to know what is the average cost of a ton of coalite as compared with coal.

Mr. Brownlie states that it is a conservative estimate to take the heating value of coalite at 50 per cent. greater than that of coal, but this estimate, without even an average figure for the cost of coalite, is not by itself quite convincing. To judge by the valuable products stated to be obtainable from one ton of average coal, it ought to be possible to obtain coalite for a very low figure. It would be interesting if money values had been given in addition to the figures referred to in the table in column 1, page 125.

The other point I wish to be allowed to make has reference to Mr. Brownlie's remarks as to the possibilities of the Diesel engine as a prime mover, and in particular his reference to the "condensing steam engine and turbine" being doomed as power producers. In anticipation of events to come there is no doubt a certain amount of truth in what Mr. Brownlie says, and no doubt the mechanical difficulties of the Diesel engine have been overcome within reasonable limits of power.

It would, however, seem that, allowing for all the progress that has been made, we are a long way off yet from the Diesel engine being developed to the sizes required for the generation of power on a large scale, such as is possible by means of the large turbine units in operation throughout the country.

In spite of its less thermal efficiency as compared with a Diesel unit, when all is said and done, no other prime mover shows so many advantages as the large turbo-generator unit for this purpose, and it would seem probable that as a commercial proposition it would pay to burn the fuel oil, obtained from coal in the production of coalite, under boilers arranged for the maximum possible economy working in conjunction with large steam turbine units. Again, it would be interesting to know at what price it is estimated it would be commercially possible to dispose of the available fuel oil obtained by the low-temperature carbonisation process.

Yours faithfully,

NOEL GREENWAY.

5A, Temple-row, Birmingham. February 7, 1922.

"COMPOUNDING OF INTERNAL-COMBUSTION ENGINES."

TO THE EDITOR OF ENGINEERING.

SIR,—As it is to certain remarks made by me that Mr. Elmer A. Sperry, New York, makes reference in the introduction to his paper, "Compounding the Combustion Engine," an abstract of which is given in your issue of last week, I beg leave to offer a few remarks on this American paper. This treatise introduces a number of side issues having no bearing whatever on the main object of compounding, and unless the claims made are subjected to very careful analysis, the results achieved cannot be rightly assessed.

(1) The system of solid injection has nothing whatever to do with compounding, and is successfully used with a variety of designs of four and two-cycle internal-combustion engine. Whether it will be more or less effective in the compound engine will depend on the qualities of fuel cleanly burnt, and the consumption per brake horse-power and per hour, regarding both of which points no information is given.

(2) The advantages of a cycle giving in practice a combination of the constant pressure and constant volume types of combustion are well known and quite widely given effect to.

(3) Detonation does not necessarily follow from such pressure volume relations during the ignition and combustion period.

(4) Claims are made for compounding in respect of saving in weight and space, but it is futile to compare an engine with crossheads, &c., running at little more than 100 r.p.m., with a trunk piston engine of light construction, the revolutions of which are 400. A figure of total weight of engine of 30 lbs. per brake horse-power is mentioned in the paper, as compared with 450 lbs. per brake horse-power. But 30 lbs. per brake horse-power for a small high-speed engine with a 7-in. diameter piston, probably rated at a high output, is not exceptional and proves nothing.

(5) The Sperry engine is a four-cycle engine, with induction at a moderately high pressure and exhausting at approximately three times the induction pressure to a large low pressure piston, the bottom side of which is used to compress the induction air prior to transfer to the high pressure cylinder.

The neat features are the use of one valve for the high-pressure exhaust to the low-pressure cylinder and the introduction of the pre-compressed induction air to the high-pressure cylinder, and the cushioning in the low-pressure cylinder minimising the exhaust gas velocity through this transfer valve. This valve, it is claimed, works well because the heat given up to it by the exhaust gases is taken up by the later incoming air, enabling it to operate at a reasonable temperature.

(6) There are certain losses which are not mentioned in the paper. Firstly, the loss of heat in transfer, *i.e.*, all the heat given up to the transfer passage and valve by the hot exhaust gases at relatively high pressure will not be picked up by the induction air. Secondly, the loss of heat during compression and transfer of the forced induction air. Thirdly, from the indicator diagram, showing the power developed during both the induction and combustion strokes in the high-pressure cylinder, must be subtracted the power required to pre-compress the induction-charge and to force it through the controlling valves and passages. Fourthly, during the period that the transfer valve is open the expanding gases forcing down the low-pressure piston will also have a retarding effect on the upward moving high-pressure piston, which must be subtracted from the low-pressure indicator diagram. Fifthly, the friction losses consequent upon reciprocating the large low-pressure piston cannot be inconsiderable.

No scales are appended to the diagrams, no figures of actual horse-powers, mean pressures recorded in the cylinders, both positive and negative, and no fuel consumptions are stated, yet in view of the foregoing remarks, in particular concerning the losses consequent upon the cycle adopted, I can only consider it as extremely improbable that the performance of this compound engine, either in power output per unit of cylinder volume or of weight of engine, or in overall efficiency, can equal the standard four-cycle Diesel engine, and if it has not these advantages it is not clear where it can have others to compensate. It is not wise in matters of internal combustion to apply directly to large sizes deductions drawn from the performances of a 7-in diameter cylinder.

Yours faithfully,
JAMES RICHARDSON, B.Sc., M.I.N.A.

BALL AND ROLLER BEARINGS: THEIR DESIGN AND PERFORMANCE.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the report on the paper by Mr. A. W. Macaulay, read before the Institution of Engineers and Shipbuilders in Scotland on December 13, 1921, which appeared in your issue of January 20, there are one or two points which seem to me are based on a misunderstanding.

The first one refers to the axial load which a ball bearing can take. It is stated that this axial load may be 25 per cent. of the listed radial capacity. From inquiries made on several occasions from the makers, I can state that this axial load can only be taken when the bearing has no radial load whatever, and that at all times the axial load admissible is only 25 per cent. of the difference between the actual radial load and the radial load given in the catalogue rating. In other words, if the bearing can carry a 1000 lb. radial load, as given in the catalogue, and if the actual load is only 800 lb., then only one-quarter of the difference, namely 50 lb., can be used as axial load.

I believe the statement regarding axial load in the makers' catalogue is usually so misleading that a good deal of trouble has followed from it, and I am anxious to correct it. I think it would be in the interest of the industry if you could obtain from the makers definite confirmation of this fact.

There is another point with reference to Fig. 3 of the paper which appears to be incorrect. The rollers used in this bearing cannot be conical as they would not be suitable for spherical adjustment in the outer race. I believe they are actually barrel shape to fit the spherical race. Fig. 3 is, therefore, incorrect as well as the text referring to it.

I remain, dear Sir, yours faithfully,
R. ORBETTICH, M.I.E.E.

Witton Works, Birmingham, February 7, 1922.

"ELECTRIC LOCOMOTIVE DRIVES."

TO THE EDITOR OF ENGINEERING.

SIR,—I thank you for your publication of my letter in your current issue and for your comments thereon. Kindly permit me some further remarks anent these latter.

The opinions I expressed were based on close and deliberate study of this subject, and I am an advocate of quill drive only because, according to my conclusions, it is the best type of drive so far made available. Are opinions any less valuable for being expressed, and does my expression of the same views from time to time mean I am not open to conviction? That is what you infer; it is, I think, a poor way to confute views opposed to your own.

In my letter I give you in detail chapter and verse for every criticism I made of your leader and for my own opinions. In your comments you have met my criticisms merely by saying that Messrs. A. W. and George Gibbs should know better than I do. Accepting this, and accepting also as quite legitimate your depreciation of my own personal experience, it is nevertheless true that these gentlemen, both of whom I bear in the highest respect and to one of whom I am indebted for much kindness, on this subject find themselves opposed to the vast majority of their fellow engineers in their own country. That this will be so here also in due course, when the subject becomes a live one, I am convinced, unless opinion is misdirected.

It is to be remembered that the quill drive in its present form was not available when the Pennsylvania design was evolved, and had it been, I question if the latter would have been evolved. That, having been evolved, it has been adopted on none of the later electric locomotive designs is surely sufficiently significant.

As for the mileage of the Pennsylvania engines, I said myself that they had done their work well, but they require and get a high standard of maintenance, and they cost more to maintain than corresponding engines. You have not contradicted this.

Regarding the perpetuation of the design on the Pennsylvania itself, I know as the latest Pennsylvania engine only that for the Alleghany Division; this is a development from the Norfolk and Western engines and both differ from the New York tunnel engines. Both have only one set of coupling rods in series against the two sets of the New York engines, and these are horizontal, coupling the driving wheels to the jackshaft which is gear, in place of being rod, driven from the motors. Though these engines are thus simpler, owing to their short rod length, I doubt their having been entirely satisfactory, but with their slow speeds, if on a good road, they may have been moderately so.

Your proposal of a trial here of rod-drive engines seems to me to amount to this, that you suggest that we should reject the experience of, the leading given by, and the information obtainable from, the results obtained abroad, and retraverse all the old ground already covered. It looks a poor proposal to me, for even if the forlorn hope of getting rid of existing defects succeeded we should only be perfecting a second-best machine, clumsy, complicated and expensive.

My idea would be to profit all we can by other people's experience, to study the causes of failure or defects in engines that are built, and to evolve therefrom with due regard to simplicity and cheapness a design on which to go forward as the basis of our own practice. If the quill design sufficiently meets our needs, including centre of gravity height, to form such a basis, and I am certain that it does, the disadvantages of the rod drive which, in its rotary-reciprocating motions, its crank-pin troubles and so on, are real and not as you suggest only attributed to it by me, are far more than sufficient to counterbalance any slight advantage a small increase of centre of gravity height might confer.

At that I think we may leave it.

Yours faithfully,
J. DALZIEL.

Derby, February 6, 1922.

"THE FLOW OF METAL DURING FORGING."

TO THE EDITOR OF ENGINEERING.

SIR,—I was very interested in your correspondent's letter published in your journal of January 27, page 104, re "The Flow of Metal during Forging," and more especially with his reference to the knowledge practical men have, which, owing to lack of expression, often remains with them. As a practical smith, one whose father and grandfather before him attained a fine degree of efficiency, I lay claim to a little exact knowledge of the working of iron and steel. My years of experience have confirmed me in the truth taught by Carlyle and Ruskin that "What thy hands perform thou mayest attain some knowledge of, and may speak with something like authority." Of other things we have little real knowledge. As a worker in iron and steel, one whose duty it is to heat these metals to all reasonable temperatures and shape them to required dimensions, I feel justified in adding support to your correspondent's statement that there is a vast amount of information lying as it were in the brain of the manipulator. What strikes me forcibly is that this knowledge is composed of numberless little things which I defy the quickest brain to detect unless the owner of it has had years of actual experience of tools, &c. In reference to the virtues of "Press" and "Hammer," for general purposes the hammer is better. The essential conditions to my mind are (1) Have your hammer heavy enough; the smith or forge hand will have the blows regulated to suit his work. I have worked hundreds of needless hours owing to having to use hammers too light for the job. For very heavy work the press comes into its own; here again the more power available the better for the smith, provided it can be regulated. I emphasise the word regulated because I have often been required to forge complicated shapes under hammers more especially which were more or less automatic—a condition of things a smith abhors. A good forging hammer should be capable of giving a single "blow" light or hard, also it should be capable of being lowered gently on to a tool or job. To ask a smith to forge complicated work under an automatic hammer is simply to restrict output; also it is severely taxing the ingenuity of the smith.

Yours faithfully,
N. S. D. WOODCOCK.

"ENGINEERING AS A PROFESSION."

TO THE EDITOR OF ENGINEERING.

SIR,—I have read in ENGINEERING the series of letters dealing with the remuneration of engineers, and the remarks of "Nabla" prompt me to put forward a definite suggestion.

To my mind the primary need in this relatively new profession is to secure for those who practise it legal protection similar to that already extended by the State to members of the legal and medical professions. Such protection, if granted, would be of advantage both to qualified engineers and to the public.

To attain this desirable end it is necessary, as "Nabla" points out, that representatives of the various groups of engineers should come together for friendly discussion. What are they to discuss? "Nabla" does not say. I do not therefore infer that he has no concrete proposals to advance, but rather that he prefers to defer his expression of them. Will he think me presumptuous, or too precipitate, if I venture to submit the following definite scheme for consideration?

I suggest that the end which I conceive to be mutually aimed at (so far unsuccessfully) by all the various groups (civil, mechanical, electrical or otherwise) could best be attained by erecting, superior to all the existing group Institutions, a new Council or Senate of British Engineers composed of delegates from those Institutions, for the purpose of obtaining State recognition of competent professional engineers and, when that end has been attained, to maintain it as an effective force, on the one hand to protect the public against incompetence, and, on the other, to secure to individual engineers adequate remuneration for their attainments and services.

Let me make it clear that I do not suggest any infringement of the rights of any existing Institution. They all exercise highly useful and necessary functions in the advancement of knowledge in the special branches of engineering with which each is concerned; but I shall find few dissentients if I assert that the whole field of engineering knowledge now transcends the capacity of any one man, however gifted. We live no longer in the times of Telford and Brunel. If we are to be competent we must specialise; but we are not by that fact precluded from acting together harmoniously in furtherance of our common interests.

If such a new body as I have outlined were constituted it should, I imagine, have no great difficulty in convincing Parliament that, in this age of engineering, the public interest demands that engineers should be competent; that competent engineers will not be forthcoming unless adequate reward is assured for the necessary and prolonged preparation by which alone competence is attainable and that, consequently, these attainments require specific recognition and protection by the State. There is a real danger, if matters continue as at present, that the best brains of the country will be diverted to other pursuits with consequent loss to the nation.

If what I have suggested is attainable, I look forward to a time when each properly-qualified engineering specialist should have the right to designate himself as

Engineer (Civil),
Engineer (Mechanical),
Engineer (Electrical),
Engineer (Naval Architect),
Engineer (Chemical),

or otherwise, as the advance of scientific knowledge may require, and also to be legally protected in that right.

I enclose my card, and from the signature I append your readers may draw such conclusion as may seem to them pertinent.

Yours, &c.,
"ICARUS."

TO THE EDITOR OF ENGINEERING.

SIR,—In ENGINEERING of the 3rd inst., page 135, your correspondent, "A Civil Engineer and Surveyor," states that "teachers give instruction in engineering . . . instead of giving instruction in ordinary subjects." I spent some years of my life as a teacher in "ordinary schools," and I entirely disagree with this statement.

The function of a teacher in "ordinary schools" is to educate, which, no doubt your correspondent knows, is not the same thing as "giving instruction." Vocational training is neither possible nor desirable in such schools; but if "ordinary subjects" are to be of use in educating, there must necessarily be illustrations and examples of their application in the world outside school.

On your correspondent's last two sentences it is unnecessary to comment; presumably he owes nothing to teachers, but has acquired such knowledge as he has entirely from his own investigations and *ab initio* in all subjects!

Yours faithfully,
FRANK KEENE.

3, Southend Parade, S.E. 9, February 7, 1922.

"FUEL IN SCIENCE AND PRACTICE."—We have received a copy of the first issue, for January, of this journal, which is "The Record of the Coal Research Club." The joint editors are Mr. R. V. Wheeler and Mr. J. V. Elsden. It gives a foreword by Sir George Beilby, and articles on "Producer Gas from Pulverised Fuel," "Coal and its Carbonisation," "The Study of Mineral Matter in Coal," "Resins in Bituminous Coal," a review of current literature and a bibliography. It is to be published on the fourth Friday in each month, the annual subscription being 10*s.* 6*d.* including postage. The address is 30 and 31, Furnival-street, Holborn, E.C.4.

THE CENTENARY OF A BIRMINGHAM FIRM.—In order to celebrate the centennial anniversary of their foundation, Messrs. Thomas Piggott and Co., Limited, Atlas Works, Spring Hill, Birmingham, the well-known manufacturers of pipe lines, gasholders, by-product and chemical plant, patent pressed steel tanks and other specialities, held a dinner on Saturday last, the 4th inst., when Alderman H. Bewlay, a director, occupied the chair, owing to the absence through illness of the chairman of the company, Mr. Arthur Ll. Lloyd. An analysis of the number of years served both by the directors and the staff showed in many cases periods amounting to very nearly half a century.

THE WORKS OF THE GENERAL ELECTRIC COMPANY AT WITTON.

THE tendency which the engineering industry shows to agglomerate into large groups is probably natural and inevitable. This applies very particularly to the electrical branch of the industry. An independent article such as a motor-car can quite well be made by a firm dealing with nothing else, but when one comes to the electric motor, which in its own sphere is an article of comparable class, considerations come in which seldom have any weight in the motor car trade. There are, of course, very many specialist firms in the electrical industry, dealing as a rule either with electric motors, or switch and control gear of some kind, and many of them are very successful, but there is none the less continual evidence of the operation of the tendency for the whole range of electrical manufacture to fall within the province of a single firm or group of allied firms.

This tendency may be explained in part by the inter-relation of many details of any electrical plant. The electric motor to which we have already referrred forms in a sense a single unit with its starting or control gear, and trouble with either the motor or starter may reflect on the other partner. Apart, however, from any question of trouble there is a natural tendency for any firm making motors to enter into the manufacture of the gear for controlling them. In many special cases they are almost forced into this position. The steam turbine and the alternator which it drives form another fairly parallel case, and the manufacture of both items is now carried out by most of the firms who are prominent in connection with either. Another feature of electrical work which leads to a continual extension of the field of electrical manufacturing companies lies in the very complicated contracts which are frequently placed for electrification work. An order for the electrification of a steel works may cover the equipment of a power station; the electric driving of rolling mills involving not only large motors, but complicated control gear; the supply and setting up of many electric motors of more normal type and size; cable work both overhead and underground and other similarly important items. It is in many ways an advantage that a complicated piece of engineering work of this class should be in the hands of a single firm, and the tendency to which we have referred is likely to become more accentuated in the future rather than to show any falling off.

In very many cases this growth of electrical manufacturing companies has come about as the result of a policy of purchase or amalgamation, although in many instances there has in addition been much natural growth. We are not sure, however, that any quite parallel case to that of the General Electrical Company, Limited, can be pointed to. This company owes its present position to a continuous and genuine growth, and so far as we are aware at no time has an important branch of work on the electrical side been added to its activities as a result of taking over other going concerns. Without implying any criticism of those who have adopted different methods, it is evident that very great credit is due to those who have built up the General Electric Company so steadily and so well. The mechanical side of the company's activities were, of course, greatly added to when the Fraser and Chalmer's works were taken over, but electrically the growth has been steady and from within. It is suggested that a realisation of the position which the General Electric Company has now reached in the building of heavy electrical machinery is not as widespread as is desirable, and with a view to giving an opportunity for an inspection of the present activities of the works at Witton a visit was organised last Tuesday. To any one not previously familiar with the work being done by the company, the visit afforded very clear demonstration that the General Electric Company must be definitely accepted as one of our leading electrical manufacturers, and as capable of dealing with any class of machine which may be required in the modern developments of power stations, steel works or mining plant. To one already familiar with these things the visit gave an opportunity of becoming acquainted with the favourable position of the company and the remarkable amount of work it is carrying through in a very lean period.

If there is any truth in the idea that the position of the General Electric Company as a manufacturer of heavy machinery is insufficiently appreciated, it may be put down to that actual natural development which is so much to its credit. The company has been in existence for some forty years, and for the first thirteen of these, from 1882 to 1895, it concerned itself with the electrical accessories business, lamps, small switches, wiring material and similar classes of goods. About 1895 it took an important step by introducing the three-phase motor into this country, and the installation which it made for the Liverpool Grain Storage Company was among important pioneer electrical works. At that time the company had a factory in Manchester, but with the growth of its activities this proved too small, and the Birmingham works were started at Witton in 1901. These have gradually grown and been added to, until to-day they are among the front rank of electrical manufactories of the country. The development of the General Electric Company has not, however, been confined to the developments which have taken place at Witton in the evolution from small machines and shops to large. It has also covered practically every branch of electrical work in a way which we think is not exactly paralleled by any other firm or group of firms, and to-day it maintains telephone works at Coventry and Salford, cable works at Southampton, lamp works at Hammersmith, glass works at Leming-

FIG. 1. MAIN TURBO-ALTERNATOR SHOP.

FIG. 2. STANDARD ELECTRIC MOTOR SHOP.

ton-on-Tyne, carbon works at Birmingham, and turbine works at Erith. This list is, we think, not quite complete, but it gives a fair index of the activities of the company.

Recent extensions at Witton comprise new switch-

gear shops and shops for the manufacture of standard sizes of electric motors, moulded insulation works and enamelling and plating shops, new administrative offices and a development department, while the foundry, main engineering shops and small motor works have been considerably extended. A large club house for the staff and workpeople has also been erected, and from its scale and completeness gives in itself a striking indication of the importance of the works of which it is an auxiliary. Of the various extensions listed above, we should like first to refer to the development department in view of its importance and the importance of the ideals for which it stands. The purpose of this department may not at first be evident to all readers from its title, and it may roughly be alternatively described as an experimental works and testing station. New designs and new methods are investigated in its shops and the first models for any new line of manufacture are built. The department contains its own workshop, electric and magnetic testing rooms, chemical laboratory, mechanical testing shops, &c. It represents the workshop side of research, and will operate in conjunction with the central research laboratory which is now being established by the company at Wembley. This laboratory and its allied research department are very clear expressions of the ideals and far-seeing views which have enabled Mr. Hugo Hirst and his associated directors to lead the General Electric Company from its small beginning to its present commanding position.

FIG. 3. GENERAL VIEW OF FOUNDRY.

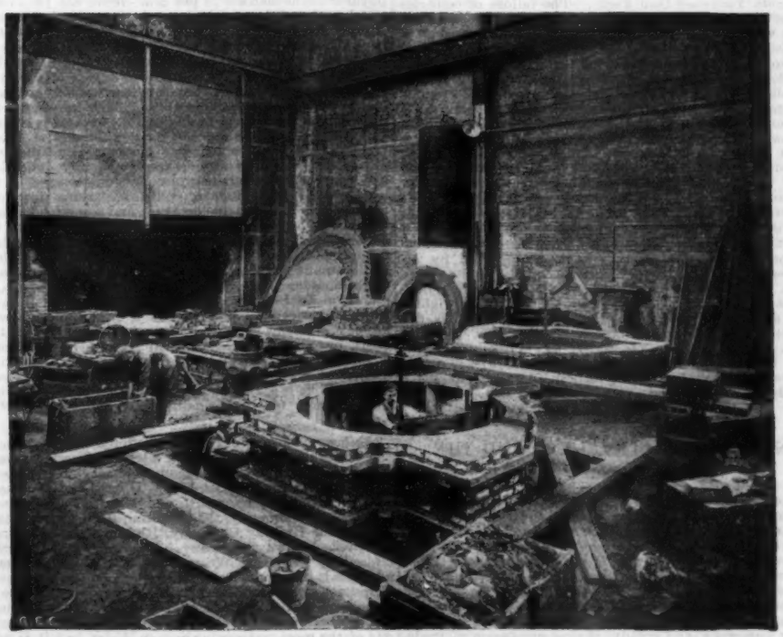


FIG. 4. PREPARING MOULD FOR 15,000 K.V.A. TURBO-STATOR.

Although in this article we cannot enter into the machine tool equipment and other features of the Witton works in any detail, we may refer briefly to the machine shops and foundry which were to some extent the special features of last Tuesday's visit to the works. The shop known as the main engineering works is divided into four bays. One of these which is devoted to turbo-alternator construction is illustrated in Fig. 1, opposite. This, as will be seen, is a good example of a modern machine and erecting shop. The machine tools are situated at the eastern end of the bay which adjoins the foundry. The equipment covers a range of lathes, milling and boring machines adapted for the machine work necessary in the building of the modern high-speed alternator and capable of dealing with machines up to, or exceeding, 25,000 k.w. capacity. The General Electric Company has always used the solid forged rotor in their turbo-alternators and the tool equipment includes a fine selection of milling machines for forming the rotor slots. Winding assembly and tests are carried on towards the other end of the bay. At the time of our visit a large number of machines was to be seen going through the shops, including one of 10,000 k.v.a. for the borough of Marylebone, one of 12,000 k.v.a. for the Bury Corporation and others of 6,000 k.v.a. and 7,500 k.v.a. for Messrs. Guest, Keen and Nettlefolds, Messrs. Bolokow, Vaughan and Co., and the Darlington and Newport Corporations. The company has also recently received an order for a 22-cycle, 22,500 k.v.a., 1,500 r.p.m. machine for the Birmingham Corporation.

The other bays by the main engineering works are devoted to slow-speed alternators, rotary converters and motors from 100 b.h.p. upwards. If of a special type smaller motors are also constructed in these shops. One bay is set apart for winding, while the others are laid out for machining, assembling, testing, &c. Two interesting rotary converters to be seen in the shops were provided with double commutators owing to the large current of 5,000 amps which had to be collected from them. The standard motor works, which is independent from these main machine shops, is laid out for the manufacture of motors up to 100-h.p. Standard types only are dealt with, and all those of special construction are built in the main shops. A view of the standard shops is given in Fig. 2, opposite. They are laid out directly from the point of view of the work they are engaged in and as the parts to be handled are comparatively light, machine service is largely looked after by jib cranes. This saves time frequently lost in waiting for the overhead cranes and assists in a continuous flow of work. Standard motors are built to jigs and templates, and all the operations are on modern manufacturing lines.

The other department which we illustrate is naturally mainly occupied in supplying those with which we have been dealing. This is the foundry of which two views are given in Figs. 3 and 4 on this page. The main part of the foundry, as will be gathered from Fig. 3 is certainly a very fine shop. It is suggested that it is the largest foundry in the Midlands. The equipment in the way of moulding and jar-ramming machines is very complete, while the bay which deals with the largest castings is supplied from three cupolas each capable of melting 25 tons of pig iron per hour. An idea of the work carried out in this bay is given by Fig. 4. Although we cannot say anything of it in detail we must refer to the new switchgear shops before closing this article. These shops are among the most admirable of their type we have have ever seen. The shops cover an area of 100,000 sq. ft. and appeared to be remarkably full of work, of which the most striking example was the new 11,000 volt three-phase main switchgear for the Neasden power station of the Metropolitan Railway. The shop is laid out in bays dealing respectively with erecting, ironclad and heavy switchgear, machining, and so on. An admirable series of closed and well ventilated departments deal with plating, enamelling, painting, &c. We noted that all paint and lacquer was put on with air brushes.

HYDRO-ELECTRIC INSTALLATIONS IN SPAIN.*

HYDRO-ELECTRIC INSTALLATIONS OF THE BARCELONA TRACTION, LIGHT AND POWER COMPANY.

By HORACE FIELD PARSHALL, D.Sc., M.Inst.C.E.

THE more important installations are situated on the Pallaresa River at Talarn and Tremp, at Camarasa, and at Seros on the River Segre, a branch of the River Ebro. The dam at Talarn, like the Camarasa dam, is built on the gravity principle, so that the unbalanced vertical weight component on the up-stream face of the dam is equal to the hydrostatic pressure. It is 262 ft. long at the base, 670 ft. long at the crest, 269 ft. high from the main floor to the crest, and approximately 328 ft. from the bottom cut-off wall to the crest. It impounds about 7,760,000,000 cub. ft. of water. The disposition of the different grades of concrete used in the dam to meet the requirements of the Government officials is indicated in a figure.

The Tremp power-house, which derives its power from the Talarn dam, is equipped with four 7,000-kw. horizontal-type turbo-generators, one turbine at each end

* Abstract of a paper read before the Institution of Civil Engineers, on Tuesday, 7th February, 1922.

of the generator. The average annual flow of the River Pallaresa over a period of years is about 49,100,000,000 cub. ft., and the output of this power-house in normal years is about 110,000,000 kw.-hours. At high-water level the working head is 249 ft., and at lowest level it is 118 ft. The latter condition, however, has not arisen, the turbines being invariably worked at the higher levels. The general results for the year 1917 show an overall efficiency of about 72 per cent., or a water consumption of 259 cub. ft. per kilowatt-hour with a head of 196 ft. to 229 ft. The water utilised in an average year at this power-house is 26,593,000,000 cub. ft. The cost of the Talarn and Tremp installation was 1,826,700*l.*, details of which are given. The installation at Aytona, or Seros, on the River Segre, of which the Rivers Pallaresa and Ribagorzana are tributaries, was the first constructed. The water is taken to the power-house by a canal 12 miles in length, while the diversion dam is at Lerida. The power-house is designed to accommodate five vertical-type generating units of 8,000 kw. (four of which have been installed), and is designed to work with 160 ft. head, the output being in an average year 130,000,000 kw.-hours. The cost of this installation is approximately 1,852,260*l.*

The most important and more recent installation described in the paper is that at Camarasa, sometimes called the "Confluence." The dam at Camarasa is about 105 ft. long at the base, 492 ft. long at the crest, and 318 ft. high from the bottom of the cut-off wall to the footway. It is 246 ft. thick at the base and contains 280,000 cub. yards of concrete. A considerable proportion of rock (plums) was used in the dam, the weight of an avergage plum being 1·18 tons. Details of the distribution of the plums, and the rate of construction, are shown graphically. The spillway was first designed to be an open canal, but subsequent investigation showed it could be more economically constructed. It was designed under Government requirements, to discharge 70,600 cub. ft. of water per second. The water is taken to the power-house through a tunnel cut through the rock and lined with cement. This tunnel is 750 sq. ft. in cross-section, 738 ft. in length, and has a fall of 6·8 ft., the fall being calculated on the basis that the power plant might be worked at full capacity when the reservoir has been drawn down to a level of 370 ft., corresponding with an effective storage of approximately 1,412,000,000 cub. ft. of water. Very liberal use was made of sand cement for the Camarasa dam, since tests indicated that this material gave an ample factor of safety. The power-house at Camarasa, which is built of reinforced concrete, is designed to accommodate five generating units of 12,500 kw. each, two of which have been installed. The capacity of this power-house completed will be 182,000,000 kw.-hours, and it is designed to utilise the 12-hour discharge at Tremp in 6 hours, should the demand for power so require. The cost of the Camarasa installation, with two units installed, is approximately 1,370,776*l.* With five units installed the cost will be increased by 375,000*l.* and the capital cost per kilowatt will be 27·9*l.* The combined output of the Tremp, Camarasa and Seros installations is approximately 430,000,000 kw.-hours, and the nominal horse-power is 180,000. The storage capacity of the reservoirs is such that 90,000,000 kw.-hours can be contributed to the combined output of Tremp, Camarasa and Seros. Results obtained from phase compensation by means of synchronous condensers are shown in tabular form. This gives the losses before and after phase-compensation, and shows a gross saving of 24,450,000 kw.-hours per annum, and a net saving, after deducting the losses in the condensers and distribution, of 18,950,000 kw.-hours. The increased revenue derived from the saving in energy effected augments the possible net income by 80,000*l.* per annum.

Preliminary calculations showed that, by the use of synchronous condensers, the power factor could be increased in the ratio of 1 to 1·3, and the terminal voltages increased in the ratio of 1 to 1·2. All predicted advantages have been fully realised in practice. The first transmission lines were equipped with pin type insulators with four petticoats, but these gave a great deal of trouble and were unable to withstand the stress of storms. The line from Seros to Barcelona, which was constructed under the author's direction, is equipped with suspension insulators, seven in series, and has stranded conductors of 250,000 cir. mils section. The line from Camarasa to Igualada has been reconstructed in order to use the suspension type of insulator, and it is equipped with six in series, of the Hewlett type. The standards are designed for straight runs with average spans of 650 ft. They are equipped with two lightning guard wires of ⅜ in. diameter, and are designed to withstand a wind pressure due to a velocity of 100 m.p.h. with ½ in. of sleet on the wires, the towers to remain stable with two wires broken. Particulars of steam and hydraulic generation at the several stations are given for the years 1917, 1918, 1919 and 1920 respectively. The results in an average year of Tremp and Camarasa are compared, allowance being made for the different features of the two installations, and particulars of the plant, kilowatt-hours generated per annum, annual river-flow, water utilised, mean head, average effective head, efficiencies and water-consumption, &c., of the two plants are given, as determined by measurement and test. The drawings show, in addition to these installations, a number of minor installations and particulars of some others that have been in contemplation, but have not yet been built.

THE JUNIOR INSTITUTION OF ENGINEERS.—The annual dinner and ladies' night of the Midland Section of this Institution was held at the Midland Hotel, Birmingham, on January 31, Mr. R. B. A. Ellis, A.M.I.Mech.E., occupying the chair. The attendance was very good.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—More pig-iron is coming into Sheffield than for some weeks past, indicating that on the whole there is more activity in the manufacturing sections. Practically the whole of the raw and semi-finished materials required is now being bought from British makers, who are benefiting from the fact that a steady decline in their productive costs has coincided with an equally steady advance in the manufacturing costs of Continental competitors, particularly in Belgium. The reduction of the official quotation for West Coast hematite to 5*l.* 15*s.* a ton, delivered in Sheffield, and East Coast hematite to 15*s.* below that figure, shows how keenly the search for new business is being prosecuted. Competition for orders in the finished steel trade is not less marked. No doubt influenced by the fact that steel-makers on the North West Coast are offering acid billets as low as 10*l.* per ton delivered, South Yorkshire makers of Siemens acid billets have reduced their quotation from 13*l.* to 11*l.* per ton. Even on this new basis business is by no means brisk, and steel furnaces are not working beyond one-third of their normal capacity. Despite the paucity of new business in the heavy engineering section, full activity is to be found in some of the principal departments, due to the recent placing of valuable contracts. The Brightside Foundry and Engineering Company have this week completed a casting of 112 tons for the River Don Works of Messrs. Vickers, Limited. This closely approached the weight of Sheffield's record casting of 130 tons. Its transport from the maker's works to the River Don works was watched with considerable interest. Another interesting development this week has been the completion by Messrs. Edgar Allen & Co., Limited, of one of the four huge steel-making kilns which are being made by them under contract for M. Basset, of Paris, in connection with that metallurgist's scheme for producing steel direct from iron ore. The full weight of the machinery under execution by Messrs. Edgar Allen's, when completed, will be 260 tons, and will furnish a revolving furnace weight of 400 tons. The despatch of the first completed kiln was made by special train comprising 20 wagons. The kiln is to be sent from Hull to France. Special railroad arrangements have been made there for its carriage to Paris. The automobile engineering section has contracted fresh depression. The manufacture of commercial lorries has been entirely suspended, works being overstocked with finished vehicles for which there are no buyers. The tool trades are doing only a scrappy business. Engineering requirements are exceptionally low, and the agricultural trade is taking nothing like its usual tonnage. A moderate quantity of files and saws is going to Russia, but makers are diffident about re-opening business on a big scale.

South Yorkshire Coal Trade.—The failure of collieries to attract anything like sufficient business to keep the pits working full time has resulted in a further general revision of rates. Best house coal has been marked down 1*s.* to 2*s.*, manufacturing fuels 1*s.* to 1*s.* 6*d.*, and slacks a similar amount. Collieries are selling unscreened smalls as low as 2*s.* 6*d.* per ton at pits in order to relieve congestion. The cold snap has given a welcome fillip to business in the house coal section. The Metropolitan demand is particularly active. Home manufacturers have not increased contract requirements substantially, insisting that further sacrifices should be made by the coal trade to assist in the stimulation of steel and engineering production. Collieries are taking export contracts at cut prices in order to retain European connections. The brightest section is that dealing with blast furnace coke, which reflects the increased activity in pig-iron making, and is further supported by an increased demand on export account. Quotations: Best branch handpicked, 38*s.* to 39*s.*; Barnsley best silkstone, 36*s.* to 37*s.* 6*d.*; Derbyshire best brights, 34*s.* 6*d.* to 35*s.* 6*d.*; Derbyshire best house coal, 33*s.* 6*d.* to 34*s.* 6*d.*; Derbyshire best large nuts, 30*s.* to 32*s.*; Derbyshire small nuts, 24*s.* to 25*s.* 6*d.*; Yorkshire hards, 27*s.* to 28*s.*; Derbyshire hards, 26*s.* to 27*s.*; rough slacks, 14*s.* to 15*s.*; nutty slacks, 11*s.* 6*d.* to 13*s.*; smalls, 2*s.* 6*d.* to 6*s.* 6*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Prices of Cleveland pig-iron are declared to have been reduced to the lowest levels that are likely to rule for some time, and indeed hints have been thrown out that slight advances may be made. Upward movement, however, is hardly likely, as any rise would probably check negotiations proceeding with markets that have been lost, and which traders are anxious to regain. Actual transactions are not on an extensive scale, but home and foreign inquiries continue fairly numerous, and steady, if slow expansion of trade is looked for. Whilst there is still some Continental competition for orders North of the Tweed, Cleveland producers expect to capture the bulk of the trade from that quarter. No. 1 Cleveland, as well as siliceous iron, is 95*s.*; No. 3 G.M.B., 90*s.*; No. 4 foundry, 87*s.* 6*d.*; No. 4 forge, 82*s* 6*d.*; and mottled and white each 75*s.* to 80*s.*, all f.o.t. or f.o.b.

Hematite.—Customers abroad, and over a wide home area are attracted to this market by the fact that East Coast brands are still the cheapest of hematites manufactured in this country. Recently fairly good sales have been effected, and with some producers now rather well placed, competition for contracts is hardly so keen as it has been. At the same time makers are anxious to secure further orders, and whilst some firms are no longer disposed to book home or foreign business at below 95*s.* for Nos. 1, 2 and 3, others are still prepared to shade that figure. No. 1 remains at half-a-crown above mixed Nos.

Manufactured Iron and Steel.—Extreme quietness continues to characterise finished iron and steel, and as yet there is little to encourage the hope of any material change for the better in the near future. Most customers appear to be holding off for lower prices, notwithstanding manufacturers emphatic declaration that quotations cannot be reduced below the already very unremunerative rates ruling. Export business can be done at below the following quotations for home trade: Common iron bars, 12*l.*; iron rivets, 14*l.* 15*s.*; medium steel billets, 8*l.* 15*s.*; hard steel billets, 9*l.* 5*s.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; steel joists, 10*l.* 10*s.*; heavy steel rails, 9*l.* 10*s.* to 10*l.* 5*s.*; fish plates, 14*l.* 10*s.*; and corrugated galvanised sheets, 16*l.*

Shipments of Iron and Steel.—January shipments of iron and steel from the port of Middlesbrough totalled 74,887 tons, of which 31,265 tons were pig-iron, 4,648 tons manufactured iron, and 38,974 tons steel. Of the pig-iron loaded last month 11,474 tons went coastwise, and 19,791 tons foreign; of the manufactured iron cleared, 46 tons went coastwise, and 4,602 tons foreign; and of the steel shipped, 3,168 tons went coastwise, and 35,806 tons foreign. Wales was the best customer for pig-iron, taking 7,650 tons; whilst Belgium received 4,940 tons; Italy, 4,832 tons; France, 4,495 tons; Scotland, 3,074 tons; and Germany, India, and Switzerland each over 1,000 tons. India was, as usual, by far the heaviest purchaser of both manufactured iron and steel, importing 3,755 tons of the former, and 16,223 tons of the latter. Other principal customers for steel were: the Argentine, 4,203 tons; Nigeria, 3,250 tons; Japan, 2,439 tons; and British East Africa, Natal and Queensland each over 1,000 tons.

Foreign Ore.—There is a little more doing in foreign ore, and values are stiffening.

Coke.—Blast furnace coke is moving upward notwithstanding protests from local consumers that it is already much too high. Medium blast furnace Durhams are fully 27*s.* delivered.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—According to the joint ascertainment of the coalowners and men's auditors for the month of December the wages payable to colliery workers for the present month in South Wales are just over 6 per cent. above the 1915 standard rates but, in accordance with the terms of the national agreement, the actual wages payable to the men are 28 per cent. above the 1915 rates, which is the minimum which was in operation in January. A statement by the South Wales Miners' Federation shows that the net proceeds of the Welsh coal industry in December amounted to 3,533,498*l.*, or 9,525*l.* less than in November, while costs totalled 3,580,015*l.*, leaving a loss of 46,517*l.*, which cannot be carried forward to be met out of future ascertainments. The total wages costs in December amounted to 2,097,914*l.*, and other costs to 1,482,101*l.* Business on the coal market is still of a hand-to-mouth character, but prices are steadier due partly to the refusal of salesmen to modify quotations and partly to reduced outputs in consequence of the ravages of the influenza epidemic having increased absenteeism in the coalfield. Best and second Admiralty large coals are now steady at 24*s.* to 24*s.* 6*d.*, with the leading Monmouthshires from 23*s.* to 23*s.* 6*d.* and best drys round 24*s.* Sized coals remain scarce and firm, while smalls of practically all descriptions are almost unobtainable. Best steam smalls by themselves command up to 19*s.* 6*d.* and seconds 18*s.* 6*d.*, with cargo smalls up to 17*s.*, but when taken in conjunction with large, and many salesmen refuse to sell except on this basis, are obtainable at a discount of 6*d.* to 1*s.* There is only a quiet demand for foundry coke, and prices are just about maintained from 32*s.* 6*d.* to 35*s.* for export, but gas coke is scarce and commands 2*s.* 6*d.* more, while inland prices for both qualities are from 35*s.* to 40*s.* at ovens.

Railway Grouping.—The terms offered to a number of the Welsh lines by the Great Western Railway Company in connection with the amalgamation scheme have been announced during the past week. Offers have been made to the Alexandra (Newport and South Wales) Docks and Railway Company, the Cambrian Railway Company, the Cardiff Railway Company, Rhymney Railway, and Taff Vale Railway Company. On the whole the terms offered by the Great Western are considered generous, and this is borne out by the fact that in all cases, except in respect to the Cambrian Railway, the market value of the shares and stock have been put up. No agreement has yet been reached with the Barry Railway Company, one of the most prosperous lines in Wales, but it is now believed that an early settlement will be reached, though it was feared that the matter would have to go to arbitration.

Shipping Company and New Capital.—The third annual report of the Bride Steamship Company, Limited, Cardiff, which owns two steamers aggregating 8,900 tons dead-weight, has just been issued, and shows a loss for the year ended December 31 last of 9,566*l.* The directors in their report state "the sum due to our bankers at the time the company's books were made up was 51,328*l.*, being considerably more than the realisable value of the security. There is also a long-standing liability for E.P.D. Under these circumstances it is either necessary to pay off the loan to the bank or reduce it by the sum of 15,000*l.*" To do this it is proposed to issue 10,000*l.*

unissued capital in the form of 100,000 15 per cent. preference shares of 2*s.* each at a premium of 1*s.* per share. "The alternative" it is stated "is that the boats will have to be sold to repay the bank's loan."

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—In the Scottish steel trade the dearth of new business is still being felt and practically no distance ahead can be seen by any of the managements. Inquiries, too, are not very encouraging yet, but perhaps a better era may be forthcoming now that the producers of this country and of England have decided on a common price policy. The meeting took place last week in London, when it was agreed that common minimum prices at all consumers' stations or sidings in Great Britain be fixed as follow:—Ship plates, 10*l.* 10*s.* per ton, and sections, 10*l.* per ton, both net. It was most emphatically stated that these quotations were not only unremunerative, but were below productive costs and were based on prospective reductions in fuel and transport charges, and that further reductions could not be looked for. This latter statement should surely reassure buyers who have been holding back business in the hope of lower rates being quoted. The competition which has been going on between the English and the Scottish makers since the latter end of last year has been most unfortunate for all, and has been all against an opening out of business. Now that a new arrangement has been arrived at a stimulus is more than probable, and perhaps consumers may be induced to place some of the long overdue contracts. Prices as now named show little difference from those of Continental producers, and when the uncertainty of delivery from the latter works is taken into account the verdict should surely lean towards the home product. In the matter of boiler plates the old agreement remains, and the current price is still 14*l.* per ton, delivered Glasgow stations. Black sheet makers, while doing a shade more on export account, are still very quiet. The general export trade all over is extremely small.

Malleable Iron Trade.—The anticipated reduction in the price of bar-iron has now taken place and at the end of last week it was decided to reduce prices to the extent of from 20*s.* to 32*s.* 6*d.* per ton, as from Monday of this week. The new quotations are now as follow:—"Crown" bars, 11*l.* 10*s.* per ton, a reduction of 20*s.* per ton; "best" bars, 12*l.* per ton, a reduction of 30*s.* per ton; and "H.S." bars, 12*l.* 2*s.* 6*d.* per ton, a reduction of 32*s.* 6*d.* per ton. The old list of extras has been restored, with the exception that on smaller sizes an addition of 50 per cent. will be levied. These quotations are for home delivery only as export lines are subject to negotiation. Business is still reported as extremely slow in the West of Scotland, but it is hoped that the new range of prices will be the means of improving the demand. Export is also very quiet.

Scottish Pig-Iron Trade.—In the pig-iron trade of Scotland very little change has taken place, and even the reduced prices quoted by producers has failed to reinforce order books. Demands are very small all round and there is little inducement to increase the output. A better feeling certainly prevails, but more than that is wanted if employment is to be improved at the works. The export inquiry shows signs of getting better, but meantime it is chiefly small lots that are being asked for. The following may be taken as the current prices:—Hematite, 5*l.* 10*s.* per ton, delivered at the steel works; foundry iron No. 1, 5*l.* 10*s.* per ton, and No. 3, 5*l.* 5*s.* per ton, both on trucks at makers' works.

PERSONAL.—Mr. A. Havelock Case, M.Inst.C.E., announces that he has been joined in partnership by Dr. Brysson Cunningham, M.Inst.C.E., who has left the service of the Port of London Authority in order to take up private practice. The business of the firm will be carried on at Broad Sanctuary Chambers, Westminster, under the style of Case and Cunningham.

THE LOCOMOTIVE BOILER EXPLOSION AT BUXTON.—The Ministry of Transport make the following announcement: The report made to the Minister as the result of the inquiry into the fatal accident that occurred on November 11 last, through the bursting of a boiler of a locomotive engine at Buxton on the London and North-Western Railway, has been placed on sale by H.M. Stationery Office, price 3*s.* 6*d.* The conclusions arrived at were that the explosion was due to considerable overpressure, and not to any weakness of the boiler; that the explosion originated in the fire-box crown, and that there were probably several contributory causes which prevented the safety valves from relieving the excess pressure, the main contributory cause being the small amount of clearance between the valve webs and the seats when cold. In regard to a suggestion which had been current that the explosion might have been due to the presence of an explosive in the fire, the report states that not only is there a total absence of evidence to support this theory, but that the nature of the damage and the course of the explosion were both decidedly at variance with it. The following recommendations are made: (1) That the final machining or fitting of the safety valve bushes should be done after they are driven into their seats, and that the valve webs should be finished to a standard and known clearance of the bushes. (2) That whenever a steam pressure gauge is changed at the running sheds the new fitted gauge should be tested against the safety valve of the engine. It would facilitate this operation if a cock were fitted on the gauge pipe to obviate the necessity of letting down steam in the boiler. Illustrations showing some of the effects and circumstances of the accident are appended to the report.

NOTICES OF MEETINGS.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, February 11, in the Lecture Theatre of the Institute, Newcastle-upon-Tyne. At 2 p.m. the President of the Institute will unveil in the Library (Wood Memorial Hall) the Memorial to Members of the Institute fallen in the war. The discussion on the "Limitations of Coal-Cutting Machinery" (adjourned from the previous meeting) will be continued. The following paper, illustrated by lantern slides, will be read: "Experiments with Single Inlet, Duplicate and Double Inlet Capell Fans," by Mr. E. Seymour Wood, M.Inst.C.E.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, February 11, at 3 p.m., in the Heriot Watt College, Chambers-street, Edinburgh, Mr. James Cooper's paper on "Measurements of Air Velocities and the Testing of Anemometers" will be discussed. Mr. Joseph Parker's paper on "The Operation of Fans in Parallel," will be discussed. A paper will be read by Mr. William Brazenall on "Pipe Friction and Pump Efficiency."

THE INSTITUTION OF LOCOMOTIVE ENGINEERS.—Monday, February 13, at 7 p.m., at the Railway Institute, North-road, Darlington, when Mr. A. Robson will read his paper on "The Inspection and Testing of Materials used in the Construction of Locomotives and Rolling-Stock." The chair will be taken by Mr. C. Stamer.

THE INSTITUTE OF TRANSPORT.—Monday, February 13, at 5.30 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. 1. Paper on "The Development of Commercial Airways," by Sir Henry White-Smith, C.B.E. (Member).

THE ROYAL SANITARY INSTITUTE.—Tuesday, February 14, at 5.30 p.m., at 90, Buckingham Palace-road, London, S.W. 1, when a discussion will take place on "The Administrative Measures necessary in regard to the Slaughtering of Animals, and the Storage and Transport of Meat, in connection with the Report issued by the Ministry of Health," to be opened by Mr. W. M. Willoughby, M.D., D.P.H., M.O.H., Port of London, Mr. J. Edwards, Member of the Departmental Committee, Mr. J. Dixon, M.R.C.V.S., Veterinary Inspector, Leeds. The chair will be taken by Sir Horace Monro, K.C.B. Friday, February 17, in the Guildhall, Norwich, at 6 p.m., when Discussions will take place on "The Carrier Problem in Disease," to be opened by Mr. S. L. Leggat, O.B.E., M.B., D.P.H., Assist.M.O.H.; and on "The Norwich Flood, 1912," by Mr. Henry Wood, A.M.Inst.C.E., Deputy City Engineer. The chair will be taken by Mr. Louis C. Parkes, M.D., D.P.H. (Vice-President of the Institute).

THE INSTITUTION OF ELECTRICAL ENGINEERS (SCOTTISH CENTRE).—Tuesday, February 14, at 7.30 p.m., in The Rooms, 207, Bath-street, Glasgow. Lecture: "The Uses of Wireless, Past and Future," with lantern slides and some experiments, by Major Jas. Erskine Murray.

THE INSTITUTE OF METALS: BIRMINGHAM LOCAL SECTION.—Tuesday, February 14, at 7.30 p.m., in the Chamber of Commerce, New-street. A paper by Professor F. C. Lea, O.B.E., D.Sc., on "Light Aluminium Alloys," will be read and discussed.

INSTITUTE OF METALS: SCOTTISH LOCAL SECTION.—Tuesday, February 14, at 7.30 p.m., in the rooms of the Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow. Papers by (*a*) John A. Sillars, on "The Production of Lead Pipes by the Extrusion Method"; (*b*) Howard J. Brand, "The Smelting and Refining of Zinc" will be read and discussed.

THE INSTITUTION OF CIVIL ENGINEERS: YORKSHIRE ASSOCIATION.—Tuesday, February 14, and Wednesday, February 15, at 7.30 p.m., in the Physics Lecture Theatre of the Leeds University. Mr. E. W. Monkhouse, M.A., M.Inst.C.E., will repeat the two Lectures he delivered in London upon "The Economic Aspects of Various Methods of Power Transmission."

THE ROYAL SOCIETY OF ARTS.—Wednesday, February 15, at 8 p.m., "The Necessity of Speech Training, and the Need of a National Conservatoire," by Mr. Cloudesley Brereton, M.A.(Cantab.), L.es.L.(Paris). Professor Sir Henry John Newbolt, C.H., M.A., D.Litt., LL.D., Chairman, Departmental Committee on the Teaching of English, will preside.

THE SOCIETY OF GLASS TECHNOLOGY.—Wednesday, February 15, at 2.30 p.m., in the College of Technology, Sackville-street, Manchester. The following papers will be read and discussed: (*a*) "The Relative Advantages and Disadvantages of Limestone, Burnt Lime and Slaked Lime as Constituents of Common Glass Batches containing Soda-Ash and Salt-Cake." Part II, by Mr. F. W. Hodkin, B.Sc., A.I.C., and Professor W. E. S. Turner, D.Sc.; (*b*) "The Density of Soda-Magnesia Glasses and the Calculation of Density in General," by Mr. S. English, M.Sc., A.I.C., and Professor W. E. S. Turner, D.Sc.; and continuation of discussion on "The Melting of Glass."

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS.—Wednesday, February 15, at 3 p.m., at Institution of Electrical Engineers, Victoria Embankment, W.C. 2. Annual General Meeting, at which Extraordinary Resolutions relating to the Articles of Association will be submitted, followed by Presidential Address by Mr. W. C. Acfield, O.B.E., M.I.M.E., Signal Superintendent, Midland Railway.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, February 16, at 6 p.m., "Rotary Converters, with Special Reference to Railway Electrification," by Mr. F. P. Whitaker, Member.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, February 16, at the Rooms of the Geological Society, Burlington House, Piccadilly, at 5.30 p.m., a paper on "The Occurrence of Silver Ores in South Lorrain, Ontario, Canada," by Mr. J. Mackintosh Bell, will be submitted for discussion.

THE NORTHAMPTON ENGINEERING COLLEGE ENGINEERING SOCIETY.—Thursday, February 16, at 5.30 p.m. Paper on "Electric Lifting Magnets: their Use and Construction for Steel Works," by Mr. J. B. Kramer (Birmingham).

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, February 17, at 9 p.m., a discourse will be delivered by Mr. D. S. M. Watson, M.Sc. The subject is "History of the Mammalian Ear." Afternoon Lectures, at 3 p.m.: Tuesday, February 14, Mr. H. H. Turner, D.Sc., F.R.S., on "Variable Stars (III) Our Sun"; Thursday, February 16, Mr. Arthur G. Perkin, F.R.S., on "Dyeing: Ancient and Modern" (Lecture I); Saturday, February 18, Mr. Ernest A. Gardner, Litt.D., on "Masterpieces of Greek Sculpture" (Lecture I).

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, February 17, at 8 p.m., at Caxton Hall, Lecturette, "Water Purification for Boiler Feed Purposes," by Mr. W. J. Lenton (Member). (Slides and exhibits.)

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, February 17, at 5.30 p.m. Extraordinary General Meeting to confirm, or otherwise, the resolution passed on January 20, 1922. At 6 p.m., Annual General Meeting, when the Annual Report of the Council will be presented, and alterations of, and additions to, By-laws will be considered. The following paper will be read: "Electric Welding Applied to Steel Construction, with Special Reference to Ships," by Mr. A. T. Wall, of Liverpool.

THE INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Friday, February 17, at 7.30 p.m., in the Mappin Hall of the Applied Science Department, the University, St. George's-square. A paper by F. C. A. H. Lantsberry, M.Sc.Tech., on "The Mechanical Properties of Metals" will be read and discussed. (Conjoint meeting with the Institution of British Foundrymen.)

PRODUCER GAS POWER PLANT: ERRATA.—We have been advised of a number of errors in the original of the paper read recently before the Institution of Mechanical Engineers, by Messrs. Denny and Knibbs, entitled "Some Observations on a Producer Gas Power Plant." The chief of these are the following, the references being to the pages on which this paper was reproduced in our last two issues:—Page 119 *ante* at the bottom of the middle column should read "in pressures (in deg. C. and centimetres of water)"—not millimetres. In the table, likewise, under pressure, mm. should be cm.—In the temperature column of this table 82·0 should be 82·7. Also in the 7th line of the paragraph preceding this table, 184° F. should be 186° F. Page 122, third paragraph from end, 9th line from end of paragraph, "motor" should read "meter." Page 153, column 3, in the formula for volume the figure 22 should be 12. In the table headed "Density of Producer Gas, etc.," from left to right the columns run CO_2, *g*, CO, *b*, &c. Page 154, title of Fig. 9 should read ". . . . saturated and at 760 mm.

AGRICULTURAL EXHIBITION AT QUITO.—H.M. Chargé d'Affaires at Quito has been informed by the Director of Agriculture of Ecuador that an Agricultural Exhibition is to be held in that city from May 26 to June 9. The Director particularly expresses the desire that United Kingdom manufacturers of agricultural machinery and implements should exhibit their products and catalogues. In order to give every facility to exhibitors, the President of the Republic has arranged for the exemption of all exhibits from customs duties, and from transportation charges both ways between Guayaquil and Quito. The conditions governing this exemption are that only one specimen of bulky machinery, such as tractors, harvesting machines, &c., shall be permitted; in the case of small implements and tools (ploughs, spades, &c.) the limit is one dozen in each class. Manufacturers intending to participate should register their names at the Department of Agriculture, Quito, before March 31. United Kingdom manufacturers who are in need of a representative in Quito to look after their interests might communicate with Mr. H. L. Williams, the local British Vice-Consul who is permitted to engage in trade.

MILAN SAMPLES FAIR.—An innovation of importance to British manufacturers at this year's Milan Fair, which will take place from April 12 to 27, will be the special group devoted to the fishing industry in all its branches, including net making machinery, rods and tackle, fish oils, fish guano, refrigerating plant, packing cases, and publications on fisheries. H.M. Consul-General at Milan states in a recent despatch that the Italians are anxious to develop the fishing industry in which they are backward, and considers that the opportunity of entering this growing market is one that British manufacturers should seriously consider. He also mentions the prevailing demand for sporting guns and sport outfits generally. The Milan Fair, as an established annual industrial market, is visited by scores of thousands of the general public and a large number of international buyers. At last year's Fair there were some 3,000 exhibitors, including 284 German, 55 French, and 39 British. The space charges at the Fair are extremely moderate under the prevailing rate of exchange. Applications for space should be addressed to the Direzione Generale, Milan Trade Fair, Viale Venezia, Milano.

AIR-COMPRESSORS FOR DIESEL-ENGINED SHIPS.

(*For Description, see Page* 179.)

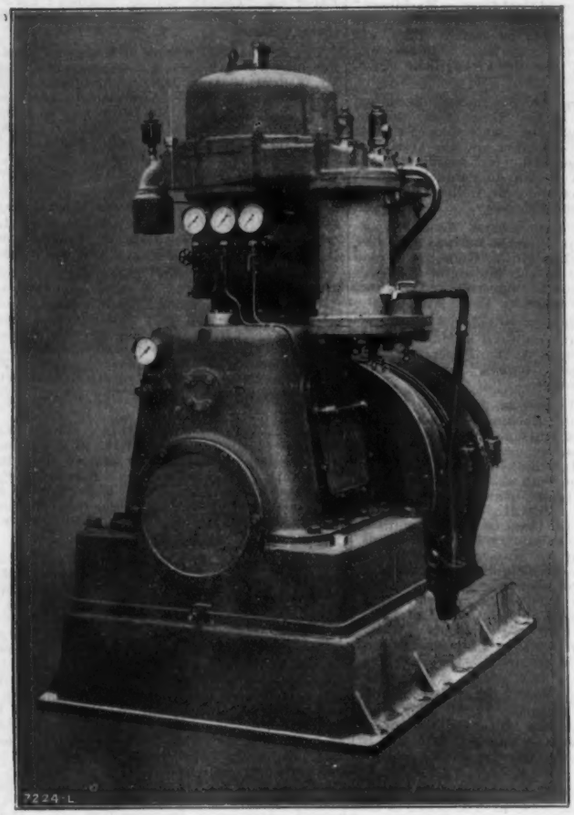


Fig. 1. Single-Crank Motor-Driven Three-Stage Air-Compressor.

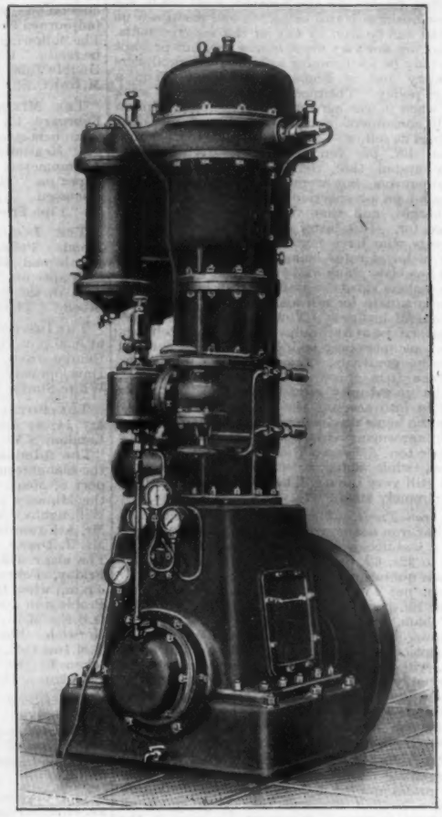


Fig. 2. Single-Crank Steam-Driven Three-Stage Air-Compressor.

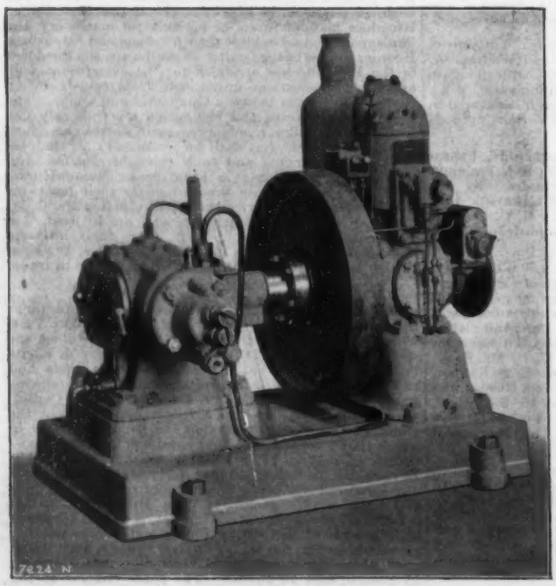


Fig. 3. Emergency-Compressor of 8 Cub. Ft. per Minute Capacity.

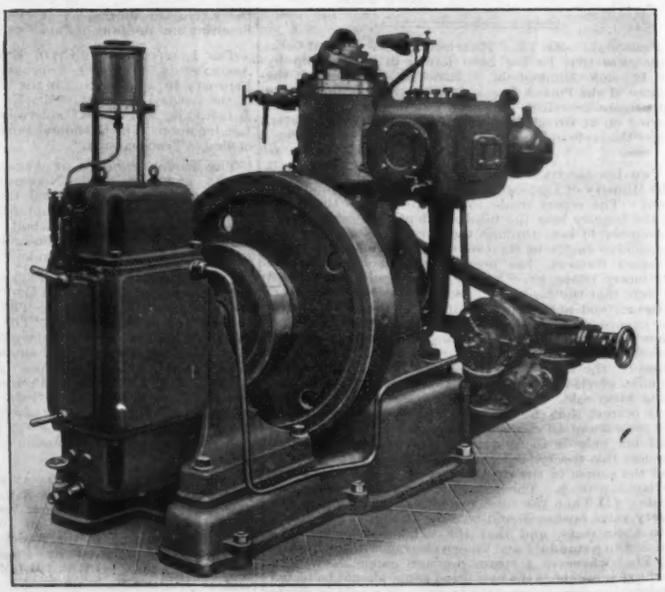


Fig. 4. Emergency-Compressor Driven by Solid Injection Heavy Oil Engine.

ENGINEERING.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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Two-Page Plate.—FIVE-TON STEAM TIPPING WAGON FITTED WITH UNIFLOW ENGINE.

ENGINEERING.

FRIDAY, FEBRUARY 10, 1922.

THE ELECTRIFICATION OF MAIN LINE RAILWAYS.

A RAILWAY company is not altogether in the position of a private trader. It has public duties which cannot be avoided. A soap manufacturer can go out of business if he wants to. A railway company hardly can. At the same time a railway company is under the same necessity as a private trader of earning a working dividend on its capital expenditure, and as a soap manufacturer will not re-equip his factory unless he can anticipate a proper return on the new expenditure, so a railway company cannot be expected to re-equip one of its lines without a similar probability. This elementary consideration appears to be frequently overlooked in the discussion of railway electrification. Railway companies are urged to re-equip this, that or the other line, either on the score of public convenience, or on the score of some supposed *per se* virtue in electric railways which steam railways do not possess.

Electric railways are, of course, very nice, and one may admit that some of the electric suburban stock working out of London is more comfortable than some of the steam stock, but even in the face of these admissions it is necessary to come back to the fact that railways cannot be electrified unless it is going to pay. In suburban working it has been found to pay, and one may take it that in due course, and especially as monetary matters become more normal, there will be a considerable extension of suburban electrification in these islands. The speeding-up and facilities for running a frequent service, which the high acceleration and elimination of shunting at terminals render possible, have been mainly responsible for the financial success of suburban electrification. The remarkable increases in passenger traffic which these features have resulted in have had more to do with this success than any reduction in operating costs. Similar results will doubtless follow the development of similar conditions in the future.

This suburban experience, which is now well established, cannot, however, be applied directly to main line working, which is now a subject of considerable discussion. The high starting acceleration and terminal conveniences which are of such importance in suburban working have little weight here, and something more is necessary to make a fair case. In certain main line instances, however, of which the line between London and Brighton may be taken as an example, it is possible that similar conditions might produce like results. The limit of suburban possibilities can only be determined by experiment, and it is conceivable that the equivalent of a suburban service to Brighton might produce the equivalent of a suburban traffic. The electrification of this line would be a valuable guide to other railways. It may be suggested that the Brighton line is a special case, but we do not know that it need be so regarded, and Professor Cramp, who introduced this point of view at the recent discussion in Birmingham, which we reported in our issue of January 27, did not mention it. He referred specifically to the lines from London to Birmingham and London to Oxford.

The question of main line electrification in this country cannot, however, be met by pretending that there are no main lines and that a frequent service of a suburban type will meet any case. The traffic between, say, London and Glasgow, can hardly be dismissed in this way. The electrical people are not the first to suggest that main lines should be dealt with as glorified suburban lines, and at the British Association meeting at Birmingham in 1913 Mr. Lanchester put forward a scheme for dealing with railway passenger traffic by means of internal-combustion engine rail cars. The matter was followed up by Colonel Crompton at a meeting of the Institution of Civil Engineers. Mr. Lanchester specifically referred to traffic between London and Birmingham, and the general lines of the argument was that a frequent service of a suburban type of rail coach with a high load-to-tare ratio would meet the conditions of passenger traffic over a hundred miles or so. Although the arguments appeared to take no account of lavatory and dining accommodation, not to mention the necessity of carrying passengers' luggage, it is quite possible that a suburban type of service might be profitably worked over longer distances than has yet been attempted. Any success which might follow work on these lines would not, however, touch the real question of main line working, which must cover both passengers and freight, and if a case for main line electrification is to be made these conditions must be frankly met.

That main line working is not glorified suburban working was very definitely recognised by Sir Henry Fowler at the meeting to which we have referred, and the unanswered question with which he wound up the meeting gives an accurate summary of the present state of affairs. What we want to know now is if the electrification of our main lines is going to pay. Although it was mainly critical, Mr. Gresley's contribution to the discussion was really more constructive than those of many of the speakers. Mr. Gresley took the pre-war cost of electrifying a mile of main line railway at 20,000*l.*, and the figure was confirmed by Mr. Willox as actually that expended in the case of the Metropolitan line. It is possible that under similar conditions the Metropolitan figure might be insufficient for some of the heavy lines, but that point may be allowed to pass, since even taking this pre-war figure of 20,000*l.* Mr. Gresley was able to show that 20 per cent. of the receipts of an electrified main line railway would be absorbed in paying interest on the capital sunk in electrification. As actually the conversion cost would be about doubled under existing conditions this 20 per cent. would really be nearer 40 per cent.

It may, of course, very reasonably be objected that in this calculation Mr. Gresley allowed nothing for extra traffic which might be obtained as a result of improved services following electrification, nor did he say anything about maintenance, fuel and other savings which electrification might bring. This is true, but it does not in our opinion affect the value of Mr. Gresley's contribution. This subject of main line electrification is suffering

from far too much loose and indefinite talk, and if any progress is to be made it will be first necessary to get back to earth and face conditions as they are. Mr. Gresley's speech put the whole question on a plane of reality. That it did not state the whole case, as we imagine it did not intend to do is, however, sufficiently indicated by the fact that the North-Eastern Railway is definitely considering the electrification of part of its main line, and one may be certain that in this consideration the incidence of the necessary expenditure has not been overlooked. Obviously the North-Eastern Company foresees savings and advantages which will outweigh the expenditure.

An actual decision to electrify an important main line requires considerable courage. The costs may be fairly estimated, but the benefits are necessarily to some extent a matter of speculation. In any normal case of suburban electrification one knows from well-established experience what the effect on passenger traffic is likely to be. No such experience exists, however, for main lines under English conditions. Foreign experience, however, and limited experience on the North-Eastern system suggests certain savings in a very definite way, and if a close estimate be made of the operating saving due to reduced fuel consumption, elimination of coaling and watering, greater working capacity of electric locomotives and advantages due to a closer approximation between the maximum speed and the average, it is very possible that a fair case could be made out for conversion of some of our main lines. An actual estimate of this kind to be of value must necessarily be worked out in considerable detail, and can only be prepared from a comparison between the existing detail records of a steam railway and all that can be learned about the detail operation of heavy electric traction elsewhere. As things stand many railway men are obviously still doubtful if main line conversion would justify itself, and as the conversion of the Brighton line would furnish valuable information to other railways on the possibilities of extra-suburban traffic, so the conversion of a portion of the North-Eastern would furnish the same thing from the point of view of main line working proper, It is much to be hoped that both these projects may be proceeded with in the not very distant future.

CONCRETE ROADS.

In the strenuous advocacy of concrete roads on the part of a comparatively small number of enthusiastic persons these gentlemen usually fall back upon the argument that such roads have proved themselves of value in the United States. We have before now pointed out that the United States, which in these days is one of the few rich countries, cannot be classed with ours in our present impoverished state, and that to adopt a big programme for concrete work on the roads here would be at the moment far beyond our means, and is likely so to remain for some time ahead.

There are in addition other points to be considered. In the first place, when motor transport arrived in the United States it was a question not of improving a moderately useful surface, but for the most part of putting down decent roads where only earth tracks existed before, and while they were about it, having to deal with a much clearer issue, those responsible wisely tackled the question boldly and decided upon the material which they thought promised to give the best serviceable life. Now those who advocate so strongly such roads over here would have us believe that in the United States this question is settled for all time. This, however, is very far from being the case, and at the present time quite a large amount of investigation work, in some cases almost rising to the level of research, is being conducted in that country on concrete and reinforced concrete road construction. This shows that the problem is still considered as being only partly solved, and while we cannot afford much money for investigations we would certainly do well to watch the work in countries where they can spend in this direction, before sinking in the country a vast amount of capital which may bring not only no adequate return, but may involve us in continual expenses.

That concrete is not indestructible, as a road surface, was amply proved by the condition into which the Brookland track got. The service in that case was severe, but it was with pneumatic tyred vehicles, and, for at any rate some time, until the surface got into very bad repair, the conditions may have been taken to resemble somewhat those of an accelerated destructive test, in which the normal traffic conditions were exaggerated to get at a result more quickly. In the United States at the present time the bulk of the traffic is with light cars. Horse traffic has almost disappeared—everybody seems to own a small car if they cannot afford a larger, farmers included. At the same time in the heavy motor traffic which has developed, the tractor and large lorry is not so common as over here, while practically all of the traffic is either on solid rubber or pneumatic tyres. The conditions here are vastly different. For generations we have had usable roads, and for a long time very excellent roads indeed, upon which farmers and others became accustomed to transport produce by means of horse traffic. Then the tractor with steel tyres developed, and these two classes have to be taken into consideration. Neither is good for concrete roads, the surface of which is liable to suffer from attrition.

Beyond these facts again is the point that, even in the United States which is held up as a model for road construction, the concrete road is, as we have said, the subject of numerous investigations, so that to jump to the conclusion that concrete would settle our problems is quite erroneous. Having taken the matter in hand probably no country has done it so thoroughly or organised its work so effectively as has been done in the United States. The work itself is laid out in long lengths so that contracting may be arranged for on the large scale, and economy in execution is encouraged, though the work is controlled by rigid and minute specifications. But this is not all. Experiments of an elaborate character have been and are being made to secure data which it is hoped will advance further the art of applying concrete to road work. For instance, a large programme was embarked upon some time ago, mainly rendered possible by co-operation on the part of road builders and road users. The prime mover in this particular investigation was the Columbia Steel Company, who was interested in testing out the use of special high tensile steel for road reinforcement. Associated with this firm were others who contributed concrete and other materials, while the United States Bureau of Public Roads, the California Highway Commission, and the Automobile Club of Southern California, all lent material assistance to the enterprise. The investigation involved the construction of an oval track of reinforced concrete, having a major axis 1,370 ft. in length, the track itself varying from 18 ft. to 20 ft. in width. The track was divided into eight sections, five of which were laid with reinforced concrete and three with plain. These sample pavings were provided to be tested to destruction by motor lorry traffic. A local firm, we understand, undertook to conduct the tests and arrange for records, while the lorries were run at the expense of the motor car dealers' association. The tests were arranged so that at first lorries of moderate weight should be used and heavier machines employed later. Instruments were placed underground for recording deflections, and numerous records were taken which when thoroughly worked up ought to yield a lot of information of a type not hitherto available. Already some results have been published in our contemporary, the *Engineering News Record*, from which some of these details are taken, but the complete results cannot be expected immediately.

The Public Roads Bureau has itself conducted various investigations. One of these dealing with the effect on roads of tyres of different kinds and in various states, was referred to by Major R. G. H. Clements, M.C., in the note he contributed to the conference of the Institution of Civil Engineers, reproduced on page 129 of our last volume. More recently tests have been carried out to show the effect of impact of rubber tyred wheels on various types of paving. In these latter a loaded box was supported by a double solid rubber tyre, and repeated blows given to the sample paving below by raising the whole through heights varying from $\frac{1}{8}$ in. to $2\frac{3}{8}$ in. and then allowing it to fall. The number of blows was 500 at $\frac{1}{4}$ in., 1,000 at $\frac{1}{2}$ in., 1,500 at $\frac{7}{8}$ in., and so on. The weight was intended to represent that for a back wheel of a 5-ton lorry, with about 1,800 lb. unsprung weight and 6,000 lb. spring-borne. This work showed in the main that slabs of $1 : 1\frac{1}{2} : 3$ concrete and at least 6 in. to 8 in. thick seem to stand up to modern motor traffic from the point of view of impact, while 4 in. would appear to be quite inadequate. The data from these tests have been arranged so as to be applicable to different conditions of traffic, and with the previous work on tyres should serve as a useful guide for dealing with the requirements of different classes of roads.

A very interesting summary of the present position of the whole question in the United States is given by Mr. A. Dryland, County Engineer and Surveyor of Middlesex, in last month's *Journal* of the Institution of Municipal and County Engineers. Mr. Dryland has recently visited the United States and travelled extensively over their roads. We gather his opinion is that while traffic remained of moderate weight plain or reinforced concrete makes a satisfactory road, but if the traffic developes so as to be classed as heavy some surfacing is necessary with asphalte or similar material. For the heaviest trafficked streets the concrete surface is not the best as a permanent proposition. With regard to cracks Mr. Dryland states these are kept filled with heavy tar or bitumen, and as a rule do not affect the traffic passing over the road. The tar would naturally act as a seal to prevent water getting down to the subgrade material; apart from its unsightly appearance the application of tar in this way seems to be open to no objection.

On the matter of the thorough-going way in which the road question is being handled in America, Mr. Dryland points out that every State university has a chair of highway engineering, while a laboratory enables tests to be carried out on materials, &c., this educational organisation being kept closely in touch with the State Highway Department. We do not know in this country a single instance of similar facilities, or of such dignity being accorded to this branch of the engineering profession.

THE SCOTTISH MOTOR SHOW.

The Scottish Motor Show, which closed on Saturday, the 4th inst., was successful at least from the point of view of the enormous amount of interest shown in the exhibits. The attendance during the period exceeded 100,000. Automobile practice is an interesting reflex of the times in which we live, and it is pleasing to record that the prices have come down very considerably within the last year. There is no startling advance in design; in fact, in a number of cases, dictated primarily by considerations of first cost and in order to cheapen production and make possible a lower selling price, reversion from high efficiency practice as exemplified by aero engines to the simpler and more standard design of engine has taken place. Economy is generally the ruling factor. Engine sizes have been gradually reduced and are still being contracted, and on show there were smaller engines than ever before. Whereas little more than a year ago 10 nominal horse-power was the average of the smaller class of two-seaters, this has been reduced to between 7 and 8, and the number of makers who offer four-seater bodies on standard 10-h.p. to 11-h.p. chassis is legion. That the performance of such vehicles meets a demand cannot be gainsaid in view of the rapidly increasing number on the road, and it is in this class of car that British makers are supreme, having mastered the exact combination of weight, power and workmanship to ensure success. The economy as regards petrol, tyres, tax, &c., makes this type of automobile a strong competitor to the American invasion, and by far the majority of exhibits at the show were examples of this class.

As regards engine design little of note is to be recorded. The sleeve valve type is certainly not losing ground, and there was on exhibition a new

and extremely ingenious form of cuff or sleeve valve which we hope fully to illustrate in the near future.

Air cooling for the smaller cars, 7 h.p. to 10 h.p., has now been established, and there are additions to this class. In one case the forced lubrication is applied, oil being circulated through partially-jacketted cylinders to deaden noise and remove some of the heat of combustion. There is wider divergence of views as regards this new class of car as between two and four-cylinder water-cooled and two-cylinder air and oil-cooled, than in any other class, as is only natural, although it can only be regarded as probable that air cooling will make headway in view of lightness and low first cost.

There are so many makes of car which now have long passed the experimental stage in respect of any salient item of their mechanical equipment, that there is little, if anything, to choose on this score, but more and more attention is being given to the body work, accommodation, access and comfort. Furthermore, these small cars are capable of sustaining relatively high speeds, and the climate of Scotland is so inclement that it is only natural that purchasers should give more and more attention to their comfort. The "all-weather" idea is the vogue of the moment. Some have a hood with side curtains, containing celluloid windows, so arranged as to open and shut with the doors. Others have a more elaborate arrangement of coachwork, but the older idea of the cabriolet body has never become really popular, because of expense and the fact that it does not really make a good open nor a good closed car. This newer type of hooded car is the more expensive, but presents a handsome appearance and truly gives an open car when required or a satisfactory fully-closed car with ample windows. The difficulty is access. In almost all cases only two doors are provided, and access to the rear seats can only be obtained by way of the offside front door, and tipping up or tipping and sliding the front seat. This is not altogether satisfactory. It is extremely difficult on a moderately-powered chassis to arrange a large body, and without such two large doors are perhaps better than four inadequate small ones. In this matter the progress which is certain to be made will no doubt solve the problems, and there is no question but that a great deal of ingenuity has been displayed in the design of coach work of this order. Of less first cost is the "all-weather" hood, with side curtains, containing windows arranged to open and shut with the four doors.

Just as the chassis with small engine running at high speed is largely a British product, the all weather body is exclusively so. There are a few makes of foreign cars which compete in this class, but in the fields of higher powered and higher priced cars the foreign cars are more numerous, and many splendid examples were shown, including twelve-cylinder V and eight-cylinders in line engines. Generally, however, where the cars *de luxe* are concerned less progress is noticed, well tried methods being almost rigidly adhered to; improvements in detail only can be recorded.

LIGHT, HEAT AND POWER.

IT is well-known that a proposed large 100,000-kw. generating station at Barking comes into the scheme for London electricity supply, approved by the Electricity Commissioners. Powers to construct such a station have been in existence for some time. The statement is now made that a rival scheme was suggested some time ago which, though rejected by the Commissioners, would have constituted an unique and most interesting development. In his presidential address before the London and Southern District Junior Gas Association, delivered on Friday, Jan. 27th, Mr. A. H. Seabrook said he did not think any super-power station such as that proposed at Barking could compare with a scheme which had been put forward in connection with Beckton. This scheme, which was evolved by the co-operation of London electricity supply companies with the Gas Light and Coke Company, suggested an electric power station contiguous to the gas works at Beckton and using the coke there produced for steam generation purposes.

This scheme opens up the broad question of co-operation between gas and electricity supply bodies. In late years we have seen a very considerable departure from the principle once so strongly held that all competition is good. It has several times been brought home to us that it can easily be developed into a system of cutting which results in economic waste. Provided that we have security against exploitation the greater good is effected by co-operation. It is virtually co-operation which enables large concerns to produce cheaply, and this is effected very largely by the elimination of waste and the utilisation of by-products. There are many instances in the industrial world of to-day in which by resorting to combination a means of utilising effectively a hitherto undesired by-product has been brought about. Mr. Seabrook, who is best known as an electrical man, points out the advantages which would accrue from closer working of the gas and electricity bodies, and promises before long several examples of this kind, which will doubtless be watched with great interest.

He points out that in many cases it would be possible to generate all the electricity required in a district, by means of electric generators driven by producer gas from the gas works coke. Above a certain limit it would be more advantageous to have a steam station employing boilers fired with coke from the gas works. At the Marylebone station the boiler plant was converted for coke-burning, with, after considerable experiment, great success and economy, and we gather the proposal with regard to Beckton was something on the same lines.

There are many of the smaller towns where there is hardly room for both gas and electricity supplies; yet both have certain advantages in particular fields so that it would be regrettable if either were eliminated. The closer co-operation of the two would enable more economical working, and would make for a much better service for light, heat and power. The gas companies were in most cases the first in the field, as regards this country. Mr. Seabrook comments on the circumspection shown as a rule in locating them, with easy access by rail, and good water supply. On the other hand many electric stations, coming rather late upon the scene, have had to be content with sites which were not at all economically suitable. One of the advantages of the Beckton scheme would be the fact that coal is brought direct in steamers to the station, and the electricity generating section would have the benefit of a by-product from the gas works practically without cost of transport.

Mr. Seabrook points out we now have an Electricity Commission developing electricity supply—why should not we have equally a Gas Commission, in the interests of the conservation of our natural resources? The full effect of thought on broad lines would then be brought about by amalgamating the two to cover light, heat and power.

THE AIR CONFERENCE.

THE second Air Conference, held on Tuesday and Wednesday last, at the Guildhall, London, was prefaced by a visit of the delegates to the London Terminal Aerodrome at Croydon, on Monday the 6th inst. During the visit the delegates were able to see something of the organisation of the aerodrome and also to inspect a number of representative examples of British commercial machines. The aerodrome is under the direction of the Controller-General of Civil Aviation and is the principal British air port and Customs station for the Continental services which have been operated from Croydon since March, 1920. Two British companies ran regular services to Paris during 1921, and additional British services to Paris and Brussels will commence operations in the coming spring. A considerable number of special flights for business or private purposes are also conducted from Croydon. The buildings include numerous hangars, workshops, offices, wireless and meteorological stations, &c., and although night flying is not yet in operation arrangements have been made to enable machines to make a safe landing after dark. The arrangements are controlled by an officer stationed on a central control tower and able to communicate with a machine in the air either by visual signals or by wireless. This officer can also control the whole of the electric night landing lights by switches placed on the tower, which is also connected by telephone to the search-light posts at each corner of the aerodrome and also to the wireless station. During foggy weather an officer is stationed on the tower to assist pilots in landing by means of wireless directions.

Landing lights are provided, in accordance with the International Air Convention for the purpose of indicating the direction in which a machine should land, or take off, at night. These are arranged in the form of two "L's" placed back to back, the long arms of the L's being in the direction of the wind, and the switching arrangements are such that the direction of the arms can be altered from the control tower if the wind direction should change. The lights themselves consist of electric lamps placed underground and protected by thick glass covers flush with the ground, so that they do not offer any obstruction to the movements of the machines. To assist pilots in locating the aerodrome from a distance an aerial lighthouse has been installed in the form of a short conical tower with a wide base. On top of the tower is a powerful flashing lamp and a number of smaller lamps, the object of the latter being to illuminate the sides of the conical tower which are painted white. In normal circumstances this light is visible at a distance of about 12 miles. Further to assist night flying, all high buildings and other obstructions, such as the wireless masts, are marked with red lights after dark. The aerodrome equipment also includes a compass swinging base and a very complete equipment for wireless communication by telegraphy and telephony which is used for distributing meteorological information, communicating with aircraft in flight and with other aerodromes, as well as for direction-finding work.

After the delegates had been welcomed by the Lord Mayor at the Guildhall on Tuesday morning, the chair was taken by Captain the Rt. Hon. F. E. Guest, C.B.E., D.S.O., M.P., Secretary of State for Air, who, after thanking the Lord Mayor for his words of welcome and encouragement, explained that the whole of the first day would be occupied by the reading of the papers which would then be discussed on the following day. The objects of the Conference, he said, were mainly to encourage and assist aviation, to afford an opportunity to review the past, both at home and abroad, to compare notes on the problems involved, and to make plans for the future. During the period which had elapsed since the first Air Conference was held the Government had not been inactive. By its research programme certain landmarks had been placed on record which would be of lasting value to civil aviation. Of these he mentioned the development of fireproofing measures, safety fuel tanks, gyro turn indicators, directional wireless, the high-lift wing, the amphibian, &c. The slow development of civil aviation he attributed to the general depression of trade and to the lack of capital in private hands; the danger of aerial navigation was also a very definite obstacle, although in this country the standard of safety attained was the highest in Europe. Last year a total of 50,000 persons were carried in 25,000 flights, but only two fatal accidents had been recorded.

The outlook as regards airships he regarded as not very hopeful. Only one Dominion had expressed a desire to join in the scheme for an Imperial airship service. He hoped, however, that the date for the final disposal of the Government airship material would be extended to June 1 next. With regard to the complaints made that the abandonment of the airship services would give the lead to other countries, he thought that there need be no fear on that score, as he regarded the developments reported to have taken place abroad as largely exaggerated. In the matter of the dispersal of airship designing and constructing staffs, he said that this would be serious if developments were only delayed for a year or two, but if, as in his opinion would be the case, a period of ten years or so had to be considered during which a heavy subsidy would be required, it would be possible to take up the whole matter again *de novo* at the end of that period at no greater cost. With regard to foreign competition in civil aviation, he thought that in the long run this had little or no prospect of commercial success in Europe. England, he pointed out, was

so well provided with railways, that it was unprofitable to develop aircraft, and this was true of Europe generally and, to a lesser extent, of America also. Too much, he added, must not be expected from the cross-Channel services from the commercial point of view, since they were competing with a highly developed system of rail and boat services. However, he wished to counterbalance these somewhat pessimistic views by referring to the possibilities of aerial transport within the wider bounds of the British Empire. He would mention particularly the prospects of mail and passenger services between England and India. This would probably be of greater value to the Empire, and of greater commercial success, than the services between Paris and London. In conclusion, he suggested that the tone to adopt at the present time was one of sure but not extravagant optimism.

CIVIL AVIATION.

The first paper read was one by Lord Gorell, C.B.E., M.C., Under-Secretary of State for Air. The subject was "Civil Aviation," and in it Lord Gorell reviewed what was being done to make aviation a practical means of communication for business purposes. It was, he said, essential to develop aviation upon fundamentally sound commercial lines, something in the way in which the Mercantile Marine had developed. There was one difference, however, that for many years to come success in the air must primarily depend upon constant scientific research. In Service flying there were two distinct purposes in view. One was for actual war purposes and the other for essential services connected with movement and supply. The future would see aeroplanes used for the movement of platoons, &c., and those trained in civil aviation would find their services called upon. He thought the suggested Auxiliary Air Force would make a valuable link between the Royal Air Force and civil aviation.

In connection with the development of airship services, it would be remembered that the Special Committee appointed in connection with the Imperial Conference reported that the best hope for successful development lay in private enterprise engaged for profit on business lines. Final replies to the question of participating in financial support for an Imperial Service had been received in the negative from New Zealand and South Africa. However, he thought airship services would in the future form essential links of the Empire, and it would be the airship which would be used for transport over great distances of seas. Although the Peace Treaty restricted Germany's activities as regards airship activity, that country had lately obtained permission to build a ship for the United States, and in other ways was keeping abreast with developments. She was granting large subsidies for internal lines. In Australia the Government was giving direct assistance in connection with three routes; the personnel employed were required to be members of the Australian Air Force Reserve. In Canada the Air Board lends airships and aeroplanes to commercial companies under certain conditions. In France the Government encouraged aviation by means of subsidies, and grants to the value of half the machine, if of specified type. In the United Kingdom Government assistance had been confined to the cross-Channel services. Very considerable developments in the organisation of weather reporting and wireless telegraphy had greatly assisted our work. It might be asked, when the figures for our work and that of France were compared, whether we or that country were pursuing the right policy. Though there was more flying in France the actual progress made was less than here, and the subsidies were considered there to have a not altogether beneficial effect. It was probable that we were really working in a sounder direction.

What was wanted to make our services successful was that the public should be convinced of the safety and trustworthiness of the services. He thought in this, British services would take the lead. Travel by air must come to be regarded as a normal means of transport for the twentieth century. In order to expedite the evolution of the ideal type of civil machine the Government had agreed to take back machines in an airworthy condition after only nine monthly payments of 2½ per cent. of their value, in order that they might be replaced by the latest types. It might be mentioned that of the 200,000*l.* allocated to the cross-Channel services, half would be spent in the purchase of new machines. The cross-Channel subsidies were necessary because our companies had to compete with the French subsidised companies. In connection with an Imperial Service the establishment and maintenance of stations would be too heavy an expense for this to be a commercial proposition. To make air mails successful night flying would be necessary, while a simplification of Customs procedure was also required. Regularity and cheapness were two objects to aim at, and companies must make efforts to attract business. He had the authority of the Secretary of State for Air for stating that it was proposed to set up a Civil Aviation Advisory Board which will be under the chairmanship of the Under-Secretary of State for Air and will comprise the Controller-General of Civil Aviation, the Director-General of Supply and Research, and it is hoped representatives of the General Post Office, Chambers of Commerce, Lloyd's, and various bodies interested in aeronautics.

PRESENT AND FUTURE AERIAL TRANSPORT.

The second paper read at the Tuesday morning session of the Conference was one by Lieut.-Colonel W. A. Bristow, entitled "Aerial Transport, To-day and To-morrow." This was not a technical paper, the author, in it, mainly confining himself to the question as to how to make civil aviation successful by attracting greater patronage. The author pointed out how the aerial transport was handicapped by heavy interest and depreciation charges for the fleet, and expense connected with the necessarily elaborate organisation. He considered the only chance of making a service a success was not to be found in greater engine or machine efficiency, but in encouraging greater traffic. On a seven-day week basis, he computed that 500 passengers were required weekly to make a service a success without subsidies. They had therefore to concentrate on really safe flying, and in this connection he thought our pilots the best in the world. He thought on the London-Paris service the machines should be of a type which could land anywhere *en route*, and more attention should be paid to landing safely and getting off. The take-off at aerodromes should be improved. Comfort should also be studied, efficient silencers being adopted, and vibration eliminated. Cabins should be warmed and pilots should establish confidence in the passengers by refraining from manœuvres liable to give rise to alarm. Facilities for luggage would have to be improved, and Customs regulations straightened out and eased. Designers should deliberately work out a bad weather type of machine so that the regularity of service might be similar to that of the Atlantic liner. If cost could be reduced, more traffic would undoubtedly be attracted. This was the only hope for a constant traffic. Many people would pay highly for one experience, but not for ordinary and regular business travelling. It was lamentable that after the Great War our commercial fleet should consist of less than twenty aeroplanes, and that whereas four years ago we had 25,000 pilots, and no less than 35,000 engines were turned over to the Disposal Board, to-day we had about one dozen first-class pilots in training.

In an appendix to this paper Lieut.-Colonel Bristow emphasised the need of greater attention being paid to making landing and getting-off safer operations. He also discussed the petrol position, pointing out that the petrol supply companies had done practically nothing to reduce the price of aviation spirit. He thought they might give a temporary rebate on petrol for commercial aviation, to help it through its early struggles. He suggested the use of a petrol log book as conducive to economy, the cutting out of taxying, and more effective supervision of tuning and warming up. A petrol economiser should also be fitted to the carburettor, so that while a rich mixture could be used on the ground, economy of 10 per cent. to 15 per cent. might be obtained on the journey itself by using a more restricted supply. Petrol should also be standardised when it would be possible to make better adjustments and considerable economy would become possible.

As, owing to limitations of space we cannot report all the proceedings of the Conference in this week's issue of ENGINEERING, we shall at once deal with the discussion on the above-mentioned two papers taken on Wednesday morning. The papers read on Tuesday afternoon and discussed on Wednesday afternoon will be dealt with in our issue of next week.

DISCUSSION ON CIVIL AVIATION.

On Wednesday morning the Conference opened with a discussion of the papers by Lord Gorell and Lieutenant-Colonel Bristow summarised above. Lord Weir occupied the chair in the unavoidable absence of the Secretary of State for Air. In opening the discussion Lord Weir said he was intensely pro-aviation. They all knew how in the past they had had continuously to sound an optimistic note in order that aviation might get anything like a fair start. It was now necessary to be more critical, and they had to confess that in the last three years they had done very little. Excepting the cross-Channel services the aeroplane had been unable to demonstrate its practicability for any purpose whatever. In Europe and America state subsidies had made possible irregular and significant services at prodigal cost. The results were incompatible with the expenditure. What was the explanation of the failure? It was due to the fact that the present aeroplane was not an instrument capable of achieving results of practical value. If the ratio of good to bad points were considered it was found deficient, but if the progress of the last three years was sustained there was very good hope for the future. By concentrating on some selected service it was possible to obtain field experience of value to designers and constructors. A steady continuance of abstract research was also requisite to make progress in new directions, if certain lines offered no further advance. What was the next big step to take? He thought it was the Cairo-Karachi route, with the assistance of the Air Force, but in that so far the experience already gained in the London-Paris service did not seem to be applied at all. He did not share any apprehension on account of our conservative attitude towards aviation. Countries fettered by wholly unsound finances were heavily backing air services at present, but that state of things could not endure. He welcomed the new Advisory Board.

Major-General Sir F. H. Sykes said what was wanted now was a realisation of broad principles; details as to subsidies, &c., were only stones in the general structure. The problem was to obtain sovereignty of the air, as we had had it of the seas, but we were now hampered by the fact that we were a poorer nation. We could not, however, forego aviation as a service. The air knew no boundaries and air power was a necessity. The reserves we ought to have would have to be drawn from commercial aviation. At present that branch could not provide them, but did form a nucleus to start upon. Progress must depend upon commercial activity. Within the Empire aviation might do a great deal by speeding up communications. Was aviation a necessity of the national life and to be afforded? Could civil aviation be developed without its military counterpart, and how best could it be supported? Those were the questions which faced us.

Colonel Armstrong, representing the British Federation of Industries, said they wanted to come to a definite conclusion as to the value of aviation to business. They thought it would be of service to industry and should receive support in its early stages. They rather felt the Government had looked too much at the military side of aviation. He thought a large force might be built up from civil aviation if properly developed. Passenger and mail services would be most valuable to commerce. The Post Office was not sufficiently sympathetic to the air mail, and took little trouble to make the service known. At present the goods carried were of no practical value to the general industries of the country. The Paris-London route was too short for the gain in time to be of service—longer routes should be developed. If reliable service to India and Africa could be developed through Egypt they would soon pay for themselves. If from India a reply could be obtained in a fortnight for a letter

fee of 8*d*. he thought the correspondence availing itself of such facilities would be considerable.

General Sir Sefton Brancker said he thought the papers and Conference depressing. They wanted new blood, and public interest needed to be roused on the subject. He did not agree with cutting down military aviation costs to give money to civil aviation. The military service had already been cut down to the limit consistent with its duties. There was a campaign afoot for abolishing the Air Ministry. That Ministry was building up soundly and efficiently a service which was likely to be of immense value to the Empire. He could not agree with Captain Guest's statement that it would be years before civil aviation would pay its way. Air transport was not ruinously expensive. The London-Paris service had a value as giving experience of air routes, but was of no business value. If the air route to India were established now he thought that in six years they might easily see mails carried to Delhi in 72 hours. Lord Gorell's paper was depressing. It suggested we should not do much for fear of burning our fingers, but some of our neighbours, having burnt their fingers, might later be found to possess transport superior to ours on all routes. If money were the only consideration, why not abolish the subsidies to the steamship companies and send the mails by sailing-ship. While everybody else was developing, we had been steadily on the decrease since our lead in the world in 1919. Why? We were divided among ourselves. The War Office and Admiralty were both trying to smash the Air Ministry—a state which would be impossible if we had a Defence Committee. The military and civil aviation sections were scarcely on speaking terms. The Air Ministry had never yet had a civil aviation policy, and they had had so many Secretaries of State that none had had time to evolve such a policy.

As a country, we always had subsidised mail services—the P. & O. was not paid by the actual stamps sold. Competition was officially encouraged, but competition among British companies could not be good in a weak industry. They had enough of competition to face in the French subsidised services, and if it existed between our own companies it went to make them unreliable. He was convinced that aerial transport would pay; but if it never would, what about the telephone service, or the many railways in the world which were run at a loss in early years? At present the Iraq-Egypt route was a military one, and did not furnish any commercial data. He would like to see a big company formed capable of working such a service backed by the Government. It was the Air League's object to bring home to the public the value of aviation to the nation.

General F. H. Williamson, who followed, spoke from the Post Office point of view. He said the provinces made good use of the London-Paris service. The letters received from Paris in 1921 were only 45 per cent. of the number sent from London to Paris by this route. Letters via Amsterdam and to places in Germany beyond showed a greater saving in time over the London-Paris service. In one month the highest number of letters sent from here to Germany by air mail numbered 480, while the Germans sent us 2,540, showing how much greater use was made by that country of these facilities. The Cairo-Baghdad fortnightly service resulted in a saving of time of 11 to 18 days. The first fortnightly mail had carried 145 letters. The average now was over 900. That was the first service resulting in a very material saving in time. The letters by air to Baghdad now amounted to 10 per cent. of the total. The Cross-Channel parcel air service was not appreciated as it might be. Ordinarily, a parcel might take a week from London to Paris. By air with the assistance of the French Customs a parcel posted in London in the morning could be delivered in Paris the same evening. The patronage received was not very encouraging. The service was still in its infancy. They had to consider regularity, cost, distance and the possibility of night flying. The service had much improved since last year, but greater reliability was needed in winter. The cost was high and additional fees must be charged; reductions in fees had not produced the expansion of business expected. On the London-Paris service the ground service took as much time as the air service. Longer services would naturally show greater saving. A special air service stamp would interfere with its utility. Now a man can affix ordinary stamps to his letter and mark it Air Mail, and it would go accordingly. To have to get special stamps would add to the difficulties.

Mr. F. Handley Page said, for passenger travel there was a distinct gain in time to Paris by the air route. It was unwise to belittle the progress being made in foreign countries in design, etc. In the United States the air mail had proved of service in conjunction with railways, enabling matter to be posted later and the mail train to be caught up *en route*. What was a commercial proposition at present? It was the running of a service at a price which would ensure some patronage. That was only possible as yet with a subsidy. He thought development would come from small companies linking up on routes, and it was better that development should come that way than in the form of big companies.

Sir Samuel Instone was inclined to ask whether they had come to the funeral of civil aviation. It was very difficult for them to interest people in civil aviation when they were told by the Secretary of State for Air that it had no chance of success. If he thought that, he would not be wasting his time there. There *was* a bright future—given the assistance they had a right to expect. He welcomed the Advisory Board, but regretted that it was not proposed to include on it any representation of the firms running the services. We could do as much as, and more than, others if we were prepared to pay as much. Nothing produced elsewhere in the way of machines, personnel, comfort or safety could surpass what we had done. Some 18 millions sterling were appropriated for flying in the country, and only £2,000,000 of this was devoted to civil aviation. He found it hard to believe that the huge remainder could be efficiently spent, and thought the cost of the Air Force might be cut down without loss of efficiency, and the sum saved made over to civil aviation. Economy might also be sought in introducing flying into the coastguard service. His firm, as was known, had utilised a private air service on business with France, with great success. So soon as aerodromes were ready, his firm would have a shot at longer routes. The conveyance of newspapers by air would be an accomplished fact shortly. He wanted British services to dominate the air by sheer force of character. People must get the air sense, as we had got the sea sense.

Sir Charles Bright said he hoped expenditure on research would not be restricted. The London-Paris service was not impressive. Out of four occasions on which he had tested it, on three, letters posted at the same time by ordinary mail had reached their destination first. The greatest future lay with the longer routes. To Australia it now took five or six weeks; by air, it might be reached in 12 days or so. He could not at present feel that aviation was a safe mode of transport, and it was certainly very uncomfortable. If the Ministry of Transport were to be continued, he thought it might take over the Air Ministry, and such officials worked into it from the latter as might be necessary.

Mr. G. F. Wood said the ordinary post-office official was absolutely ignorant of the conditions of the air services. Speed was the quintessence of commercial aviation, and anything which tended to reduce the gain in that direction militated against it. They wanted the services to have the support of the whole country and not merely of London. He thought France might be approached to make Le Bourget an international terminal point, and not merely a transit station or junction for British and other routes.

A communication was read by the Chairman from the Chinese Chargé d'Affaires to the effect that already services existed in China, where the advantages of aeroplanes as regards time of transit were considerable over railroads or water transport. By the time mail routes had reached out to the East China services would be ready to meet them.

Mr. Ashbolt also expressed disappointment with Captain Guest's remarks. Statements such as those had not, and could not, build up the British Empire. Lord Gorell had suggested that airships and aeroplanes should develop side by side. He agreed. The only good point in Captain Guest's speech was the statement that respite had been given till the middle of the year with regard to the disbandment and distribution of airship personnel and material. Commercial finance was available for aviation if the necessary preliminary work was done by the Government. Railways had often been encouraged with land grants. Aviation required costly ground services which were difficult to provide at first. When the ground work was furnished by Government the airships would come in and reduce the time of transit and then revenue would become a factor. He put forward another plan in the event of the Empire proposals considered by the Premiers' Conference falling through. This now depended upon India. If India refused to join in, the whole scheme fell through.

As an alternative, he would propose that the Government make arrangements with Germany so that that country could make part of its reparation payments in aviation material. It might be argued that that would mean less work for this country; but if the scheme fell through there would be no work to be done at all, whereas British labour might still be utilised for the preparation of the bases, &c. Germany should also be asked to supply three or four commercial airships. He would, however prefer that the Empire should find the million pounds required by the original scheme.

Col. Barrett-Lennard thought Captain Guest's attitude open to criticism. He had thrown cold water on the whole thing. Could there properly be an Air Minister who did not believe in the air. One company alone had spent more on getting a service going than the Government had spent on all of them in subsidies. The Government terms were one-sided. Their loss was limited—that of the companies unlimited. Subsidies to the English firms were necessary because the French Goverment had fixed on a basis which was not an economic one. With an increase of traffic there would be greater hope of making the outgoings and incomings balance. If the question was one which depended upon traffic the situation would not be improved by spreading out this traffic over larger ground charges.

A resolution was then put forward to the effect that the conference called on the Government to consider the establishment of air-mail services throughout the Empire in the interests of greater speed of communication. This was carried unanimously.

The conference then adjourned till the afternoon. The report of the adjourned discussion, &c., as already mentioned, will be given in our next issue.

(*To be continued.*)

NOTES.

The Secretaryship of the Institution of Civil Engineers.

The official social functions of our engineering institutions might lose in conviviality if subject to the chilling influence of public record, but we venture to make an exception as to this year's dinner given by the president, vice-presidents and council of the Institution of Civil Engineers to the past-president, Mr. John A. Brodie, because the occasion was appropriately utilised to give tangible expression of the appreciation of the past-presidents, and the council of Dr. J. H. T. Tudsbery's twenty-six years of service as secretary, and to welcome his successor—Mr. H. H. Jeffcott, B.A.I. Mr. Brodie, in reply to the toast of his health, referred to Dr. Tudsbery's judgment, wisdom and tact, to his character, to his firmness when necessity required, and to his kindliness and help to the younger members of the Institution. In the future, he added, the work would not be less important than in the past, and the Institution recognised that with the new secretary they could feel confident that they would go on and prosper. The president, Mr. W. B. Worthington, made the presentation, which took the form of a beautifully-engraved oval rose bowl having the inscription: "Given by the members of the Council of the Institution of Civil Engineers to J. H. T. Tudsbery, D.Sc., as a mark of their high appreciation of his services as secretary during the past twenty-six

POWER STATION ECONOMY IN GREAT BRITAIN.

Generating Stations in Great Britain. Statistics for Year Ending March 31, 1921.
Stations Consuming Coal or Coke.

Group. (Based on Total Output of Station during Year.)	No. of Stations.	Total Units Generated (From Coal and Coke).	Total Coal and Coke Consumed Tons.	Average Coal Consumption. Lb. per Unit Generated.	Lowest Coal Consumption at any Station. Lb. per Unit Generated.	Highest Thermal Efficiency for any Station. (Approximate.)
						per cent.
A. Over 50,000,000 units ..	20	2,280,150,737	2,763,407	2·71	1·78	17·75
B. Between 15,000,000 and 50,000,000 units	56	1,554,034,615	2,276,096	3·28	2·19	14·28
C. Between 3,000,000 and 15,000,000 units	114	891,026,983	1,656,811	4·16	2·56	13·91
D. Under 3,000,000 units ..	273	230,302,068	660,443	6·42	1·70	15·50
Totals	463	4,955,514,403	7,356,757	3·32	1·70	17·75

Note.—Where the calorific value of the fuel was not specified in the returns, the following average values have been taken for calculating the thermal efficiency, viz.: Anthracite, 13,000 B.Th.U.; coal, 10,500 B.Th.U.

years, and of their regard for him as a friend. February, 1922." Mr. Worthington said that Dr. Tudsbery had spent the best part of his life in the service of the Institution, where he had made an enormous number of friends, mostly amongst those who had seen most of him. He, like the past-presidents, the past members of council and the present members of council, recognised the help, support and store of knowledge which Dr. Tudsbery had placed at the service of the Institution. Dr. Tudsbery had a vast experience of men and matters, which was of great value to all connected with the organisation. They were fortunate that, in his capacity as honorary secretary, the Institution would continue to benefit from time to time from his experience, and he was quite sure that the new secretary would readily utilise that help and assistance until he was thoroughly fixed in his seat. Dr. Tudsbery, in his reply, expressed great gratification that they had not only recognised his work, but that they had taken the opportunity when there were so many past-presidents of the Institution present. He regretted the unavoidable absence of Sir Guilford Molesworth, who was the sole survivor of the council as he first knew it. Proceeding, he referred to his work with Sir Thomas Hawksley and Lord Kelvin, and expressed his confidence in the future of the Institution. He remarked that there had been many changes, but to him the Institution was always the same body; there was no substantial change, but there was continuous advance, the Institution deliberately and cautiously moulding itself to fit changing times and the changing spirit of the time. He gave a hearty welcome to his successor, and would readily relinquish to him the steering wheel. He did not need to give him "the course," for he knew that already; he would have to luff occasionally to the squalls, but he was confident that in the most extreme event he would keep good way on the ship.

Power Station Economy in Great Britain.

Experience in the early days of power station engineering showed vast discrepancies between the coal consumption of engines working under test conditions and the average standard attained in everyday running. Of course, even at their best, the engines were far from economical if viewed from the standpoint of to-day, and this relative inefficiency was aggravated by the low load factor with which the old-time power station had perforce to be content. The load was almost exclusively a lighting load, and the highest peak in the load curve generally corresponded to the time of the day at which people were dressing for dinner. The demand for power has created a day load and enormously improved the load factor, which is generally highest in industrial areas. This improvement in the load factor has materially diminished the gap between the average fuel consumption at a station and that attained in special tests. Some very interesting figures on this head have just been published by the Electricity Commissioners. These figures are based on the four-weekly returns rendered by 501 electricity stations in Great Britain for the year ending March 31 last. As will be seen from the above Table the stations have been classified according to output and perhaps the most remarkable feature in the report is that the lowest consumption per unit was attained at a small station, which presumably had a specially good load factor. It is curious, however, that though the lowest coal consumption was recorded at this small station, yet the thermal efficiency was notably less than at the best of the large stations, a matter which would seem in need of further elucidation. Comparing average with averages the large station is, however, much more efficient than the small. In the discussion on Mr. Baumann's paper read at the Institution of Electrical Engineers last April. Mr. J. N. Thwaite stated that on test at Carville an actual overall thermal efficiency of 25·87 per cent. had been recorded with Parsons turbines of 10,000 kw. rated output. This figure is based upon the heat actually supplied to the turbine at the stop valve, and for direct comparison with the best figure given in the above table would require correction for radiation losses and for the energy expended in driving auxiliaries. The gap between individual performance and station performance is thus very much less than in the early days of power station practice. The report also classifies the stations by areas; the leading place being taken by Northumberland, where the average consumption of coal or coke has been 2·08 lb. per unit. In Lancashire, which has been handicapped by its foolish craze for municipalisation, the coal consumption per unit generated has been 3·22 lb. per unit. The 463 steam stations dealt with in Table I generated, it will be seen, nearly 5,000,000,000 units during the year. At waste heat stations 161½ millions were generated, the next place being taken by stations in which oil engines are used. These had an aggregate output of 23¾ million units. The report unfortunately gives no data as to the oil consumption per unit. Stations operated in conjunction with destructors supplied 17½ million units, whilst from water power only 4¾ million units were derived and from gas driven stations only a little over 4,000,000 units.

THE LATE SIR GEORGE J. CARTER, K.B.E.

At a time when the industry has the greatest possible need for wise counsels, the shipbuilding world has lost one of its ablest leaders by the death of Sir George J. Carter, which we regret to record occurred yesterday, the 9th inst., at his brother-in-law's residence, Brettanby Manor, Barton, Yorkshire. Sir George was perhaps best known as the managing director of the Birkenhead Yard of Messrs. Cammell Laird and Co., Limited, a position he had occupied since the latter part of 1912. He was thus responsible for the valuable constructional and repair work carried out by that firm during the war period, but his public work in connection with the shipbuilding industry, some of which we shall refer to later, was probably of even greater importance to the country and must have had a material influence on the outcome of the struggle.

The subject of our memoir was born in 1860, so that he was in his sixty-second year at the time of his death. He was educated privately, and at the early age of 14 years commenced a seven-years' apprenticeship as a shipwright with H.M. Dockyard, Portsmouth. The first three years of his apprenticeship were spent in practical work at the ship's side and in the shops, and for the remainder of the period he was occupied in the mould loft and drawing office. After completing his apprenticeship he was employed for four more years in the drawing office at Portsmouth, and in 1885 entered the service of Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited (at that time Sir W. G. Armstrong, Mitchell and Co.). At Elswick he was engaged on the design and construction of all types of war vessels, as well as a number of merchant ships, being made shipyard manager in 1894 and later being appointed a director of the company. Of the more notable warships constructed at Elswick during Sir George's management we may mention the British battleships Superb and Monarch, and the battle-cruiser Invincible, as well as the Brazilian battleship Minas Geraes. It was to Sir George Carter that the original proposal to construct the new Armstrong Yard at High Walker-on-Tyne was due; he was also responsible, with the late Mr. J. R. Perrett, for the general lay-out of the yard, a detailed account of which was given in a series of articles published in our 109th volume.

On resigning in 1912 from his position at Elswick to take up the appointment as managing director of Messrs. Cammell Laird's Birkenhead Yard, he became responsible for the organisation and working of that establishment, which covers an area of 108 acres and includes 12 building berths, 7 graving docks, fitting-out basins and the necessary shops for shipbuilding and repair work on the largest scale. The yard and its equipment, which were largely augmented and reorganised under Sir George Carter's control, were fully described in our issue of June 18, 1920, on page 812, in connection with the Liverpool meeting of the Institution of Naval Architects in that year. Some particulars of the war work carried out there under Sir George's supervision were also given in that article.

The full responsibility for such an organisation during the war period might well be regarded as a sufficiently heavy burden for any man, but to this Sir George added the very onerous duties attending the chairmanship of the Merchant Shipbuilding Advisory Committee and, later, the membership of the Shipbuilding Council. Sir George also acted as deputy chairman of the Liverpool Munitions Committee, and for the greater part of the war period was President of the Shipbuilding Employers' Federation, a position for which his strong personality combined with exceptional powers of clear expression and great skill and tact in conducting negotiations, rendered him eminently suitable. It was in recognition of his services to the nation in the directions we have mentioned that he was created a Knight Commander of the British Empire in 1917. There can be little doubt, however, that the origin of the illness which has now terminated fatally must be ascribed to the physical and mental strain involved in carrying out the very heavy duties thus undertaken from purely patriotic motives.

Of the other public offices held by the deceased we may mention that he was a member of the Council of the Federation of British Industries, a member of the Committee of Lloyd's Register of Shipping, and a member of the Mersey Docks and Harbour Board. He was also a member of Council of the Institution of Naval Architects, a member of both the Institution of Civil Engineers and the Institution of Mechanical Engineers, and a Freeman of the Shipwrights' Company. Sir George leaves a widow and two sons to whom the sympathy of a very wide circle of personal friends will be very heartily extended. Unfortunately his health for some months past has been such that he has been unable to take a very active part in the management of the Birkenhead establishment, but his loss will nevertheless be keenly felt by the directors, staff and employees of that concern. By the latter particularly he was highly esteemed for the sympathy and straightforwardness with which he handled any matters in dispute, and that these qualities have characterised his whole career may be gathered from the fact that on his resignation from the Elswick Works, he was presented by the employees with a particularly handsome silver service—a possession which he prized very highly.

NOTES ON NEW BOOKS.

A book dealing with a subject that enters indirectly only within our scope, but one of very great importance nevertheless to all French mining, sanitary and other engineers and leaders whose duty it is to direct large bodies of operatives, is entitled "*Applications de la Biologie a l'Art de l'Ingénieur.*" It treats of a number of diseases brought about by parasites of both the animal and the vegetable kingdom, by bacteria, and indicates the remedies to be applied for their cure and also for their prevention. A special chapter covers the precautions to be taken in cases of illness due to excess of pressure in compressed air, to rarefied air, toxic gases, dust and smoke, &c. The author is Dr. Ed. Imbeaux, chief engineer of roads and bridges, whose authority on the subject is well-established. The book is published at the price of 13·50 francs, by Mr. Dunod, 47 and 49, Quai des Grands Augustins, Paris 6.

In the "draft tube" the velocity of a fluid is converted into a pressure head by letting the fluid pass down a suitable tube to impinge upon a flat plate or a cone. The problems involved are not novel, but they seem to have received more theoretical than prac-

tical study. The publication in our issue of August 19, 1921 (page 293), of the experimental research on the hydraucone regainer, contributed by Mr. W. M. White, of the Allis-Chalmers Manufacturing Company, of Milwaukee, induced Messrs. C. A. Parsons and Co., of Newcastle-upon-Tyne, to send us drawings of a similar type of "diffuser" for colliery ventilation fans, one of which, coupled directly to a steam turbine and still in use, they had installed in 1903 (see ENGINEERING, November 11, 1921, page 659). In his pamphlet on "*Die Saugstrahlturbine*," Professor Hans Baudisch, of Vienna, also deals mainly with turbine problems; but he does not fail to point out that his considerations would apply to hydraulic machinery generally. Connecting the original researches on these "suction-stream turbines" with the names of Budau, Prášil and also Kaplan, he discusses in this volume of 47 pages [Leipzig and Wien, Franz Deuticke, price 10 marks] the advantages and disadvantages of straight and expanding draught tubes and of tubes which are once or several times deflected in curves or with sharp corners. Examples are worked out, but the deductions are entirely theoretical and not supported by any special experiments; this applies also to the recommendation of rimless wheels. References are made to the work of White and others. As regards the spacing of the blades in the wheel, Professor Baudisch calculates that the sum of the arcs of the blades need not make up more than one-half and possibly not more than one-fifth of the whole circumference. This latter figure seems very small, though it is now recognised that close spacing is not advantageous. The attempt to treat the "blade range," *i.e.*, the space within which the deflecting influence of a blade is felt in the water passing through the wheel, as a three-dimensional problem is novel, we believe; but it is not carried far owing to want of experimental data.

In 1908 Dr. Norman R. Campbell, now a member of the research staff of the London General Electric Company, wrote a "Treatise of Modern Electrical Theory." In order to keep up with the amazing developments of science, he is supplementing this treatise by a number of monographs which bear the titles of the respective chapters in the original treatise. The first of these monographs, published by the Cambridge University Press, Fetter-lane, E.C., price 10*s.* 6*d.* net, deals with "*Series Spectra*." Nowhere, perhaps, does the student of thirty and more years ago feel so hopelessly bewildered as in the domain of spectroscopy. The old simplicity is gone. Every element has several different spectras all of a confusing complexity, and it is often difficult to understand how an element is identified by its spectrum, even in the laboratory, let alone in stellar nebulæ. If the atom itself is a miniature universe, we cannot expect simplicity of the spectra; but spectroscopy was supposed to help us to simpler views. Yet there seems to be no end to the resolution of lines by the Zeeman and Stark effects, and if a line finally has any breadth left, that is ascribed to the Doppler effect. All the series lines are supposed to be determined by the differences of certain "terms"; but the terms themselves are calculated from measurements of the lines. That this is not arithmetical jugglery, and that the complexity of the spectra is in accord with modern views on the structure of the atom, the quantum relation and the principle of relativity, though partly in conflict with Maxwell's theory and with classical dynamics, is ably exposed in this excellent critical monograph of 110 pages. The book has to be studied carefully, of course. The few illustrations, mere diagrams, do not include any photographs of spectra. Dr. Campbell particularly acknowledges the help he obtained from Sommerfeld's "Atombau und Spektrallinien"; the treatment of the subject is his own.

AGRICULTURAL TRACTOR TRIALS.—With further reference to these trials, to which we called attention on page 104 *ante*, the Society of Motor Manufacturers and Traders has sent us a draft of the rules and regulations under which they are to be carried out.

THE LIVERPOOL SALVAGE ASSOCIATION.—This association held their annual meeting on Friday, January 27, when Mr. F. R. Edwards, the chairman, said that during the year their officers were engaged in a few small salvage cases which did not call for any comment; this was because of the absence of casualties within the association's immediate sphere of operations, largely, no doubt, on account of the great number of vessels which had been laid up. Their steamer, the Ranger, was the finest salvage steamer afloat. It was proposed to replace other vessels by new ones, of greater power and towing capacity, one of which would be stationed on the South Coast. The plant at Liverpool had been extended and renovated. They now possessed pumps of a total capacity of 12,000 tons of water per hour, most of them being motor pumps, all of the same make, the parts being therefore interchangeable. They would welcome a visit of inspection from any shipowners or others interested in salvage work. Mr. Edwards was re-elected chairman for the ensuing year.

A NEW DEVELOPMENT IN MARINE PROPULSION.

THE contract which was placed recently with Messrs. Scotts' Shipbuilding and Engineering Company, Limited, Greenock, for the construction of a 400-ft. twin-screw vessel for Messrs. Alfred Holt and Co., of Liverpool, has attracted a considerable amount of attention in engineering and shipowning circles throughout the country on account of the departure made in connection with the propelling machinery for which Scott-Still engines have been adopted. In an association extending back to 1865, the firms of Scotts' and Holt have been responsible for many important advances in naval architecture and marine engineering, and it is fitting that they should be associated now with the latest development in marine propulsion.

The engines for the new vessel will be constructed under licence from the Still Engine Company, Limited, 7, Prince's-street, Westminster. It is gratifying to know that the Still engine is a purely British production in its inception and subsequent development. Scotts' Company directed their attention in 1916 to the slow-running merchant type of marine Still engine, and have designed and constructed an experimental single-cylinder unit of about 400 b.h.p., with which they have been carrying out an extensive series of trials at their works. The first of these trials was made in May, 1920. Following upon the trials made by French engineers,* dealt with in our issue of September 2 last, Captain H. Riall Sankey, M.I.Mech.E., in October last conducted a series of trials, and his report, now available, is appended to this description of the machinery installation for the new Holt liner. The improvements introduced from time to time will be incorporated in the engines for the present contract.

The Scott-Still engines for the Holt vessel now ordered will have a combined brake horse-power of 2,500 when running at from 115 r.p.m. to 120 r.p.m., under ordinary service conditions. Each set of main engines will have four cylinders, 22 in. diameter, with a stroke of 36 in. The engines will be of enclosed type with forced lubrication to all the principal bearings. A group of pumps will be driven by levers and links from the crankshaft at the forward end of the engines, and will embody those required for the operation of the main engines, with the exception of the valve gear operating pumps, and the scavenging blowers which will be motor driven. All the usual engine-room auxiliaries, and the winches (11 in number) and the windlass will also be motor driven. The steering gear will be of Hele-Shaw Martineau type. Electric power will be supplied at 220 volts by two 160-kw. Diesel-driven generators, running at 250 r.p.m., and one generator of 50-kw. capacity driven by a Diesel or semi-Diesel engine. For starting these engines a compressor set will be provided. It is intended that one large generating set will supply the electric power required at sea and normally in port. When all the winches are in operation, the power will be supplemented by the 50-kw. set. A small lighting set of 12-kw. capacity at 110 volts, with a semi-Diesel engine, will also be provided capable of being started by hand, and a rotary converter will be fitted. A special feature of the installation is the absence of high-pressure air compressors. The thrust blocks will be of the Michell type. The present intention is to carry out a series of test-bed trials of the main engines at the works before fitting them on board the ship.

Some particulars of the characteristics and broad principles which have influenced the design of the Scott-Still engine will be of interest. The engines consist of an ingenious combination of oil engines and steam engines. The main source of power is oil consumed within the cylinder for the down stroke, operating on the two-cycle principle, while steam forms a supplementary source of power, being used upon the up-stroke. The oil fuel is injected into the cylinders without the use of high-pressure air. The engines are designed to reduce heat losses to a practical minimum, the primary consideration being to accomplish this in such a manner as to improve the thermal conditions of the working cylinders and so ensure the maximum efficiency from the fuel burnt therein. The combustion cylinder liners are of special form to secure immunity from heat cracks. On each cylinder top there is only one opening, and no separate cover is required for the combustion cylinder. Forming an integral part of each engine there is fitted a regenerator which is constructed like a small oil-fired water-tube boiler, and supplies steam for starting and manœuvring the engine. When the engine is started, the oil burners are shut off, and the regenerator then serves merely as a steam and water reservoir with which the water in the combustion cylinder jacket is in circuit. The heat from the jacket water, and that recovered from the exhaust gases through the medium of the regenerator and the feed heater incorporated therewith, all goes to form steam which performs useful work on the steam side of the engine pistons. The thermal working conditions of the cylinders result in the compression pressure being considerably less than in the ordinary Diesel type of engine. The valves on the steam side of the cylinders are operated by oil under pressure, which simplifies and facilitates the control of the engine for starting-up and while manœuvring. An impressive feature of the Scott-Still engine is the absence of the complicated array of rods, valves and cams associated with the ordinary Diesel engine. The results obtained from the experimental engine at Scotts' Works show that the Scott-Still engine has an advantage in fuel economy over the best Diesel engine; but even more important, from the shipowner's point of view, is the fact that the space occupied by such an installation and the weight of machinery in sea-going trim are considerably less than with Diesel engines of the same power. It will be seen that the Scott-Still engines have many novel and attractive features, and the results of the new Holt vessel will be awaited with the greatest interest.

The following is the full text of the report on the test of the "Still" engine carried out on October 5 and 6, 1921, by Captain H. Riall Sankey, C.B., C.B.E., R.E. (retired).

The Object of the Test.—The object of this test was to observe the general behaviour and, more particularly, the fuel economy of a "Still" engine as far as could be done with an experimental unit.

The "Still" engine, in the design for marine purposes shown to me by Messrs. Scott, consists of groups of three cylinders working on a three-throw crankshaft; the top of each cylinder works as a two-stroke oil engine and the bottom as a steam engine. The steam is produced in a boiler by the heat transferred from the combustion part of the cylinder to the jacket cooling water and from the hot gases of the exhaust. The steam first enters the bottom of one of the cylinders which acts as an high-pressure cylinder and, after expansion, into the bottom of the remaining two which act as low-pressure cylinders. The steam is then condensed in the usual way, and is pumped back into the boiler through a feed-heater (heated by the exhaust gases) and the cylinder jackets.

The engine tested was one cylinder, such as would be combined into a group of three as above, the steam portion representing one of the low-pressure cylinders. The high-pressure cylinder of the group was improvised out of a single-acting steam engine working on an extension of the crankshaft of the main engine. Its cylinder was jacketed with exhaust gases, which no doubt improved the economy of this cylinder, but not sufficiently to make it as economical as the high-pressure cylinder of the group of three cylinders for reasons which will be given later. This auxiliary steam engine also added to the mechanical losses.

Method of Testing.—Many tests had previously been made with this experimental engine in accordance with a carefully-thought-out plan by a staff of observers who had become expert in taking the various readings. After due consideration I adopted the method of testing in use and thus my test may be regarded as concurrent with this series, and it may be said at once that it is in agreement with these previous tests. In support of this statement Fig. 1 [on the next page] is referred to, where it will be seen that the differences are well within the permissible errors in such tests.

The load was applied by means of a Froude hydraulic brake and the speed was regulated by hand. The fuel oil was measured by means of calibrated cylindrical tanks of small diameter, the readings being taken on external gauge glasses. Indicator diagrams were taken of the combustion cylinder, of the high-pressure and of the low-pressure cylinders. Pressures and temperatures were measured at numerous points, the latter by thermo-junctions and by mercury thermometers.

Calibrations.—The weights for the Froude brake were calibrated and its leverage checked. Readings of the oil measuring tanks were checked by weighing. The gauges were compared with a standard.

Two days, October 5 and 6, were occupied with this test; on the first day, full load, three-quarter load and half-load trials were made, and the second day was taken up with an overload trial and the various calibrations.

The duration of each trial was regulated so as to get a reliable measure of the fuel economy of the engine; its endurance had been already adequately tested on a previous occasion by a continuous 14 days' run at full load.

A peculiarity in testing this machine is that after a substantial change of load (say, from full to three-quarter), some little time must elapse before the temperature distribution throughout the engine and the weight of steam settle down to the regime of the new load, and during this time no useful readings to obtain fuel economy can be taken.

The scavenge air was obtained by means of a blower, and after correcting for air blown away to waste to overcome certain surging difficulties due to this form of blower when employed to scavenge a single cylinder, it was found that the horse-power required was as follows:—

Overload.	Full.	Three-quarter.	Half.
20·7	17·7	13·5	6·5

This horse-power has been deducted from the horse-power absorbed by the brake to obtain the effective horse-power given in Table I [on the next page].

Throughout the test the engine ran perfectly and

* See ENGINEERING of September 2, 1921, for description of the Still engine and for extracts from a report of tests carried out by a deputation of French engineers.

with very little noise; there was a marked absence of the jar usual in internal-combustion engines—in fact, it ran like a steam engine.

Results of the Test.—The essential results of the test are given in Table I below. In Fig. 1 are plotted on an "effective horse-power" basis the total oil consumption,

TABLE I.

Dimensions of Engine.

Main Cylinder: Stroke .. 36 in. Bore .. .. 22 in. diam. Piston rod .. 6½ in. diam.
Auxiliary H.P. Cylinder: Stroke .. 22 in. Bore .. .. 14 in. diam.

—	Over-Load.	Full Load.	Three-quarter Load.	Half-Load.
Pressures. (Gauge, Lb. per Sq. In.)				
1. Maximum in combustion cylinder ..	615	595	600	585
2. In boiler	114	112	111	111
3. Admission to engine ..	96	78	50	29
4. Exhaust of engine (inches mercury) ..	26·5	26·9	26·8	25·9
Temperatures. (Degrees Fahrenheit.)				
5. Exhaust gases (boiler inlet)	756	678	579	494
6. Feed water	78	76	79	78
7. Exhaust gases to atmosphere	156	164	161	181
8. Steam in boiler ..	347	346	345	345
9. Weight of steam passing through engine (lb. per hour) ..	1,025	802	583	355
M.E.P. referred to Combustion Cylinder.				
10. Combustion	89·53	81·37	71·27	56·63
11. Steam, high-pressure	5·10	3·86	2·07	1·12
12. Steam, low-pressure ..	6·46	6·14	4·75	2·72
13. Total	101·1	91·4	78·1	60·5
14. R.P.M.	129·3	125·0	111·3	97·4
15. I.H.P. combustion cylinder	400·5	351·5	274·1	190·6
16. I.H.P. total	451·7	394·7	300·3	203·5
17. Brake load (lb.) ..	1,500	1,380	1,125	850
18. H.P. absorbed by brake	387·9	345·0	250·4	165·6
19. Brake efficiency, per cent.	85·9	87·4	83·4	81·4
20. H.P. used in scavenging	20·7	17·7	13·5	6·5
21. Effective H.P. ..	387·2	327·3	236·9	159·1
22. Ratio, effective H.P. to total I.H.P., per cent.	81·3	82·9	78·9	78·2
23. Total oil consumption per hour, lb. ..	147·2	126·7	90·9	61·0
24. Oil consumption per combustion I.H.P. per hour, lb. ..	0·367	0·360	0·332	0·320
25. Oil consumption per effective H.P. per hour, lb.	0·401	0·387	0·384	0·383
26. Thermal efficiency I.H.P., per cent. ..	38·4	39·2	42·5	44·1
27. Thermal efficiency, effective H.P., per cent.	35·2	36·4	36·7	36·8
28. B.Th.U. per minute per C.I.H.P. ..	110·4	108·2	99·8	96·2
29. Ditto per effective H.P.	120·6	116·4	115·5	115·2
30. Lubricating oil per hour, lb.	0·6	0·6	0·6	0·6
31. Smoke ..	Slight haze	None	None	None

TABLE II.

—	Over-Load.	Full Load.	Three-quarter Load.	Half-Load.
Thermal efficiency of ideal engine	50·0	50·8	55·0	51·6
Thermal efficiency of actual engine ..	38·4	39·2	42·5	44·1
Efficiency ratio	76·8	77·2	83·3	85·4

TABLE III.—*Economical Results that may be expected in a Three-Cylinder Unit when the Steam is exhausted into a Low-Pressure Turbine driving the Air Scavenge Blower.*

—	Over-load.	Full Load.	Three-quarter Load.	Half-load.
Total I.H.P.	463	404	302	206
Effective H.P.	404	359	256	172
Brake efficiency, per cent.	87·2	88·8	84·6	83·2
Oil per effective H.P. (lb. hour)	0·364	0·353	0·355	0·355
Thermal efficiency per effective H.P., per cent.	38·7	39·9	39·7	39·7
B.Th.U. per minute per effective H.P. ..	109·6	106·3	106·8	106·8

the oil per effective horse-power per hour, the thermal efficiency, the British thermal units per horse-power per minute and the ratio of the effective horse-power to the indicated horse-power at the various loads. Also, by way of comparison some of the results of the trials made on May 10, 1921, by the French engineers.

Attention is called to the following facts:—

(*a*) The remarkable fuel economy and the corresponding high thermal efficiency.

(*b*) The small change in this economy from half to full load.

(*c*) The capability of considerable overload at a comparatively small increase in fuel consumption per effective horse-power.

(*d*) The high brake efficiency for a high compression oil engine.

(*e*) The low consumption of lubricating oil.

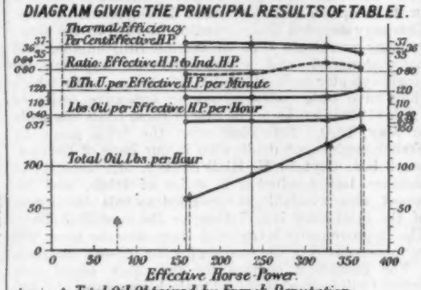
(*f*) The low temperature of the exhaust gases on final discharge.

(*g*) The entire absence of smoke, except a slight haze at overload.

Thermal Efficiency and Efficiency Ratio of Combustion Cylinder.—At full load, the indicated horse-power developed in the combustion cylinder was 351·5, the oil consumption was 126·7 lb. per hour, and since the lower calorific value of the oil is 18,053* B.Th.U. per pound, the thermal efficiency was 39·2 per cent. The thermal efficiencies for the other loads are given in Table II.

These thermal efficiencies have been compared with those of an ideal oil-engine working between the same temperature limits as the actual engine at the various

DIAGRAM GIVING THE PRINCIPAL RESULTS OF TABLE I.


Thermal Efficiency
Per Cent Effective H.P.
Ratio: Effective H.P. to Ind. H.P.
B.Th.U. per Effective H.P. per Minute
Lbs. Oil per Effective H.P. per Hour
Total Oil Lbs. per Hour
Effective Horse-Power.

(7233) △ *Total Oil Obtained by French Deputation.*

loads; these temperature limits have been obtained by the use of a temperature-entropy chart, and the thermal efficiencies calculated, taking account of the variation of specific heat. The results obtained are given in Table II.

Thermal Efficiency and Efficiency Ratio of Steam Cylinders.—At overload, 1,025 lb. per hour of steam (saturated) passed through the high-pressure and low-pressure cylinders. In the case of the high-pressure cylinder the indicated horse-power developed was 22·8, corresponding to a feed of 45 lb. per indicated horse-power hour. The admission pressure was 111 lb. absolute per square inch, and the exhaust 22 lb. absolute per square inch, and for these steam conditions the feed of the Rankine engine is 21·5 lb. per indicated horse-power hour. Hence the efficiency ratio was 47·8 per cent., which is distinctively low for an high-pressure cylinder.

For the low-pressure cylinder the following are the corresponding figures:—

Indicated horse-power developed	28·9	
Feed	35·5 lb. per indicated horse-power.	
Rankine feed	17·1	,, ,,
Efficiency ratio	48 per cent.	

Usually the efficiency ratio of the low-pressure cylinder of a condensing engine does not exceed 40 per cent. to 45 per cent. owing, mainly, to the loss caused by "cutting off the toe of the diagram." The higher value of 40 per cent. in this case is due to the heat transmitted from the combustion cylinder.

It cannot be doubted that in an actual marine engine of the type previously described where the high-pressure cylinder is at the bottom of a combustion cylinder, so that the steam receives heat during admission and expansion, the efficiency ratio of this high-pressure cylinder would be at least 90 per cent. As regards the low-pressure cylinder, an efficiency ratio of 90 per cent. can be expected if the back pressure be increased to the release pressure by passing its exhaust into the low-pressure portion of a mixed pressure turbine provided for driving the scavenge air blower. This turbine should be supplied with a small amount of steam direct from the boiler to make up the power required by the blower, and for regulating purposes.

In the experimental engine tested a certain amount of the exhaust gases was used for jacketing the high pressure cylinder (auxiliary engine); in the three-cylinder unit this waste of exhaust gases would not occur and a corresponding additional weight of steam would be produced in the boiler.

The mechanical losses of the auxiliary steam engine were included when determining the horse-power absorbed by the brake, but in a three-cylinder unit they would not occur. The auxiliary engine is single-acting and judging from general experience its mechanical efficiency at 40 lb. M.E.P. would be about 90 per cent., which works out to a loss of horse-power equivalent to 0·0342 × revolutions per minute. Being a single-acting engine, the loss is practically constant at all loads, and this horse-power can therefore be added to the effective horse-power.

The calculations to ascertain what improvement in economy may be expected, based on the above, are given in Table III.

January 25, 1922. H. RIALL SANKEY.

* As reported by Mr. Harry Stranger, Broadway House, Westminster.

AMERICAN WARSHIP PRACTICE.

MR. S. V. GOODALL, of the Royal Corps of Naval Constructors, who during the war served in the United States as liaison officer for naval construction, delivered a lecture on "American Warship Practice" at a meeting of the Portsmouth Engineering Society on January 31.

The chairman, Mr. G. E. Suter, O.B.E., M.V.O., in his opening remarks said that the lecture would be of interest to all who were in any way connected with ship-building and engineering. Mr. Goodall was specially qualified to speak on this subject.

The following abstract has been officially supplied to us. A picture was first shown of the U.S.S. Tennessee, and attention directed to the most interesting features. The main armament and propelling machinery were then described at some length. The lecturer stated that the 14-in. triple turrets of this vessel resemble in their main features the 16-in. triple turrets of later ships. In designing these turrets economy of weight and space has evidently been regarded as of primary importance. The guns are very close together, the breeches rotate downwards instead of to the side, and the trunnions are situated close to the front shield plate. There are two shell hoists for the three guns. The shells are stowed on their bases in the mounting and the fixed structure just inside the ring bulkhead. The lift is consequently short, and space in the hold usually allocated to shell rooms is saved. The guns are loaded at a fixed angle; a complete deck below them provides protection to the ammunition working spaces. Electro-hydraulic machinery is installed for the various operations, most of which can also be performed by auxiliary motors driven from storage batteries. Space in the barbette for walking pipes and in the ship for hydraulic engines is thus saved. In commenting upon these turrets the lecturer stated that while the resulting economy in weight and space has an important effect upon the design of the ship as a whole these advantages are bought at a price. The turrets are cramped, the machinery and working parts are difficult of access for overhaul and repairs, and the system adopted for the supply of ammunition, particularly of shells to the centre gun, seems open to grave objections. He preferred hydraulic to electro-hydraulic machinery and thought the noise of the latter in the turrets he had inspected very disconcerting. In discussing the relative advantages of triple and twin turrets, the lecturer said that if the fire from, say, six guns in two turrets were as rapid and accurate as that from six guns in three turrets the former could be incorporated in a superior ship as the economy in weight and space would outweigh the "too many eggs in one basket" argument, but from his knowledge of American experience, such a standard of rapidity and accuracy of fire from a triple turret had not yet been achieved.

The propelling machinery of the Tennessee comprises eight oil-fired Babcock and Wilcox boilers fitted with superheaters. Each boiler is in a separate watertight compartment situated on the outboard side of the two engine-rooms so that the steam pipe system is simple and direct. Each of the two engine-rooms contains a turbo-generator with its exciter and booster and the various auxiliaries necessary to the main propulsion, these being electrically driven. Just abaft the engine-room is the main control room. The four main motors, which can be operated as 24 or 36-pole machines, are in three separate watertight compartments. At full power the generators, which are three-phase, run at about 2,000 r.p.m.; each develops 12,000 kw. at about 3,600 volts and 35 cycles. From full speed (21 knots) to 17 knots the corresponding revolutions of the motors (170 to about 135) are governed by regulating steam supply; throughout this range the motors are connected to the 24-pole winding. Below 17 knots only one generator is required and the motors can be connected either to the 24 or 36-pole winding. For best economy at speeds below 15 knots the motors are connected to the 36-pole winding. It is difficult to compare results obtained from electric propelling machinery with those from geared turbines because there are no vessels of the same class fitted with both types. All that can be done is to compare the data published for the New Mexico and Hood. The machinery of the latter develops 2½ times more shaft horse-power per ton than that of the former. The engine-room space in the Hood is such that she develops three times more shaft horse-power per square foot than the New Mexico. Even in steam consumption the advantage lies with the geared turbine installation. On the other hand, with electric propelling machinery it appears possible to subdivide the vessel more minutely as there is no mechanical connection between the turbine and the propeller shaft; *per contra*, the electric machinery is more vulnerable against shell fire owing to the presence of bare bus-bars and large ventilating trunks for motors and generators.

The system of protection against gun attack adopted in the latest American battleships consists of a long, rather narrow, heavy belt (13½ in. thick) terminating in transverse bulkheads of the same thickness with a heavy deck 3½ in. thick on the top, the whole forming a box which is intended to be invulnerable. Before and aft this citadel is a still heavier deck below the waterline. An interesting feature is the armour round the funnel uptakes and the trunk supplying air to the boiler and engine rooms; this is essential otherwise the heavy deck is weakened by the presence of holes which a lucky shot might find.

The underwater protection consists of a system of longitudinal and transverse bulkheads; the former are closely spaced and the latter are staggered. Five wing compartments are so formed, the innermost and outermost are air spaces and the centre three are oil fuel tanks. In addition, the vessel is further subdivided. This system was adopted after an extensive series of trials on a large scale. A description was given of the main features of the Lexington class of battle cruisers and others.

BOILER EXPLOSION ON A FISHING BOAT.

UNDER the provisions of the Boiler Explosions Acts, 1882 and 1890, a preliminary inquiry has been conducted by the Board of Trade with regard to the circumstances and cause of an explosion which occurred on June, 27, 1921, on board the fishing boat Mary Thomson when off Lossiemouth, four of the crew being injured, but fortunately afterwards recovering. The vessel was owned in equal shares by Messrs. Campbell, Main and Stewart, Lossiemouth. From the report on his examination of the exploded boiler, addressed to the Board of Trade by Mr. W. L. Mennie, one of their surveyors, we gather the following particulars.

The boiler was of the vertical type usually provided in small fishing boats to supply steam to the capstan. It was made of steel and was 2 ft. 4½ in. in diameter and 4 ft. 4 in. in height. The firebox was 1 ft. 10½ in. in diameter, and was provided with one cross water tube 8¾ in. in diameter. The external diameter of the uptake was 8½ in. and originally it had been ½ in. in thickness. Provision for the inspection and cleaning of the boiler was made by four hand holes. Three of those were 4 in. in height by 2⅞ in. in width; the fourth hand hole, which was 6½ in. in height by 4¼ in. in width, was cut in the shell plate opposite to the uptake tube, and its position was such that the condition of the uptake could be clearly seen when the door was removed. The usual mountings, including one spring loaded safety valve, adjusted to lift at a pressure of 90 lb. per square inch, were attached to the boiler.

The boiler was made by Messrs. Elliot and Garrood, Beccles, in June, 1910, and was therefore 11 years old. No repairs had been done and the boiler was not inspected or insured.

The explosion occurred with a loud report. A portion of the plate forming the uptake was blown out, leaving an irregularly shaped hole about 2½ in. square in area, through which a part of the contents of the boiler escaped. The explosion was due to the uptake plate having wasted until it was no longer able to withstand the steam pressure to which it was subjected under normal working conditions.

In his "General Remarks" included in his report, Mr. Mennie says that "in June, 1910, Mr. John Stewart became part owner of the fishing boat Mary Thomson, and shortly afterwards an explosion occurred from the boiler which was 12 years old, through a small portion of the plate at the back of the uptake being blown out. The boiler to which the present report refers was then installed in place of the one which had failed. Early in 1919 a motor engine for propelling purposes was supplied to the vessel, and Mr. Main and Mr. Campbell took shares in the boat with Mr. Stewart, but neither of the former two appeared to have taken an active part in the management, and it was left entirely to Mr. Stewart to keep the boat and its equipment in proper condition.

"The boiler was in constant use for five months each year and during the remaining seven months steam was raised occasionally for pumping out the boat. Since the boiler had been installed the raising of steam and the cleaning of the boiler had been carried out under the supervision of Mr. Stewart who also acted as skipper. The date of the last cleaning was June 3, 1921, when Mr. Stewart carried out the work.

"On June 26, 1921, the Mary Thomson left Lossiemouth for the fishing ground, and on the same day, at 11 a.m. the boiler fire was lighted. The next day at 11 a.m. when the steam pressure had reached 60 lb. per square inch the explosion occurred. The after cabin was filled with steam, scalding four members of the crew who were there. The boat then returned to Lossiemouth, when the injured men received medical attention and one was detained in hospital.

"Each of the owners admitted, in evidence, that he knew of several previous explosions of a similar nature to that which had now occurred, and that notwithstanding this knowledge, no steps were taken to have the boiler inspected by a competent person. It was also stated that it was not the local practice to have such boilers inspected."

Mr. Mennie concludes his report as follows:—

"I examined the boiler after the explosion and found that the uptake tube had wasted on both sides of the plate. The corrosion had been most active on the water side, particularly near the working water level and where the thickness of the tube ranged from ⅛ to 1/32 of an inch. As a result of my examination I am of opinion that an inspection by a person competent to inspect boilers would have revealed the dangerous condition of the uptake for some considerable time prior to the explosion; and also that when the boiler was cleaned on June 3 last the plate that failed was then so thin that it would have fractured had the rust been removed by a hammer."

Reviewing the above report, Mr. Carlton the Engineer Surveyor-in-Chief to the Board of Trade, adds the following observations:—

"In view of the skipper's experience of a previous explosion from the uptake of the boiler formerly installed in his boat, it is remarkable that he did not exercise greater vigilance and care on the present boiler to maintain it in a safe working condition, especially as the boiler was placed in a comparatively small space situated close to the living spaces occupied by the crew.

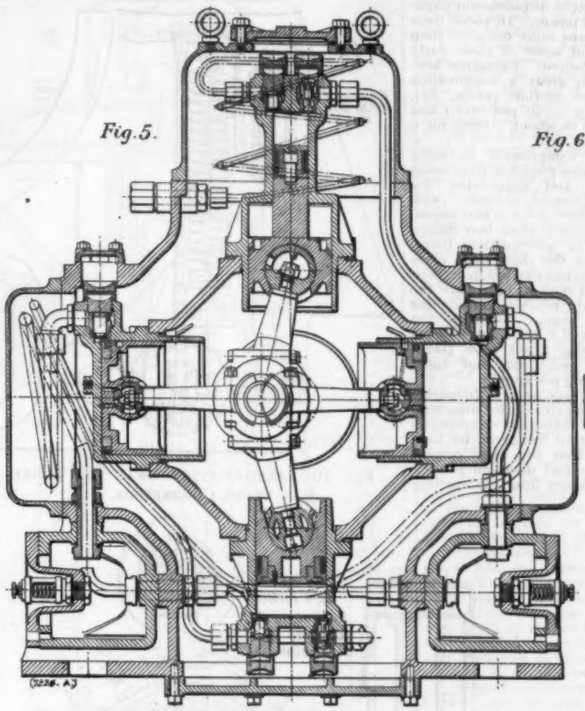
"If, as appears in this case, the owners are themselves not competent to maintain a boiler in good condition or to judge of its fitness for service, they should obtain the services of a competent person to inspect the boiler periodically on their behalf."

CONTRACTS.—The tender of Messrs. Pratchitt Brothers, engineers, Denton Iron Works, Carlisle, amounting to 2,230*l.*, has been accepted by the Faversham Rural District Council for the supply of certain pumping machinery for the water supply of Boughton.

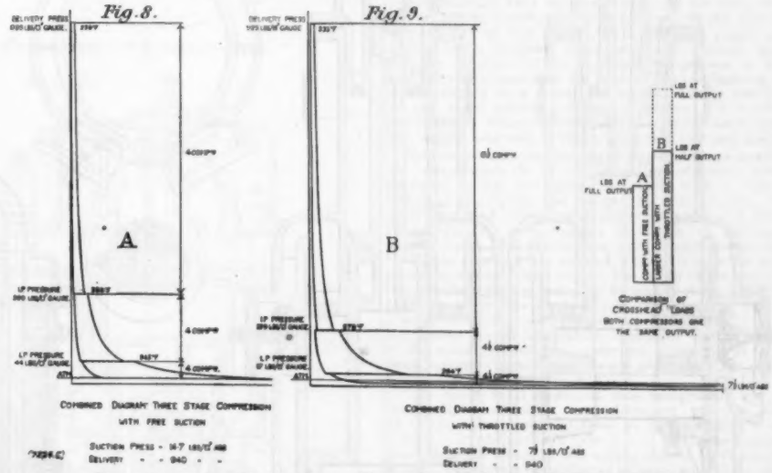
THE USE OF COMPRESSED AIR IN DIESEL ENGINED SHIPS.*

By WILLIAM REAVELL, M.I.Mech.E., M.I.N.A.

COMPRESSED air, as a medium for injecting and pulverising oil in the cylinder of a Diesel engine, was the recognised practice in the earliest engines of that type using liquid fuel. To use this form of energy for starting purposes was obviously a concomitant step. Until marine engineers began to develop the Diesel engine for use in ships, the compressor, driven from the engine itself, together with storage vessels of ample capacity, was usually all that was required to ensure sufficient air being available for these purposes, although in a few installations having a number of Diesel engines, an independently driven compressor was installed as an additional safeguard. For that purpose electrically driven sets have been used, the rule being to make them of the same capacity as any one compressor on the Diesel engine sets.



FIGS. 5 AND 6. QUADRUPLEX THREE-STAGE COMPRESSOR.



FIGS. 8 AND 9. DIAGRAMS OF THREE-STAGE COMPRESSOR, A AND B.

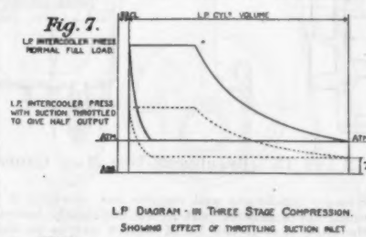


Fig. 7.
L.P. DIAGRAM - IN THREE STAGE COMPRESSION.
SHOWING EFFECT OF THROTTLING SUCTION INLET
PRESSURE RANGE - 4 COMPRESSIONS IN EACH CASE.

FIG. 7. DIAGRAM SHOWING EFFECT ON L.P. CARD OF THROTTLING THE SUCTION.

When the Diesel engine was introduced for marine work and designed for running in either direction, it became necessary, in order to provide ample security, to use storage bottles or air receivers of considerably increased capacity, together with ample compressor capacity for charging these receivers. This led to a divergence in practice, as compared with Diesel engines for fixed installations on land.

For the latter engines it is found that an allowance of 7 litres (or say a ¼ of a cub ft.) of free air displacement in the low-pressure cylinders of a three-stage compressor per brake horse-power per minute of the Diesel engines is an ample allowance, giving a margin for recharging the starting bottles in a reasonably short time. This capacity is the displacement volume of the low-pressure cylinders of the air compressor, and in the three stage quadruplex compressors (Figs. 5 and 6), designed by the author and built by his firm (large numbers of which are in use on engines up to 1,000 b.h.p. to 1,200 b.h.p. for electric lighting and other power purposes) the volumetric

* Abstract of a paper read before the North-East Coast Institution of Engineers and Shipbuilders Newcastle-on-Tyne on January 27, 1922.

efficiency may be taken as an average at 90 per cent., giving 6·3 litres of free air compressed and delivered per brake horse-power per minute. Some larger installations fitted with such compressors, of only 6 litres capacity instead of 7, are found quite satisfactory.

The allowance made for air-compressor capacity in early Diesel engines was much greater than this, 12 or even 14 litres (½ cub. ft.) per minute displacement capacity being used per brake horse-power. In those days two-stage compression was perhaps more common than three-stage, and the efficiency of some of these early compressors left much to be desired. Excessive low-pressure cylinder clearance, too great a compression ratio in that cylinder, defective suction valves, &c., reduced the volumetric efficiency to 60 per cent., and the equivalent free air delivered to about 7 litres for a displacement of 12 litres.

The adoption of two-stage compression in early engines, with the high temperatures resulting from using eight compressions per stage, and aggravated by throttling the air to the low-pressure cylinder (with results to which the author will refer later in this paper) was probably even more responsible than bad design for the troubles experienced in air-injection Diesel engines in the past. The use of the three-stage compressor, coupled with the improvements which experience has dictated in its detailed design, has made the modern air compressor an entirely reliable and efficient component of the Diesel land engine. Recently the author received a record of a run of 2,500 hours without opening up, the compressor being fitted to a Diesel electric lighting engine, seven years old, and doing altogether over 5,000 hours running per annum.

Marine Diesel Engines—Main Compressors.—In marine work, the desire for ample storage capacity for manœuvring air has led to the practice of fitting air compressors of much larger size than the author has given for land installations, the reason being that the large surplus above that actually required for fuel injection is used for rapidly replenishing the air taken from the starting bottles.

be admitted that when a Diesel ship reaches the open sea it will be running continuously for a longer period at full load without stopping than a Diesel engine on land, and therefore that the economies referred to, which would result from fitting a smaller compressor, are worth consideration.

It is, of course, known that a steam engine will run

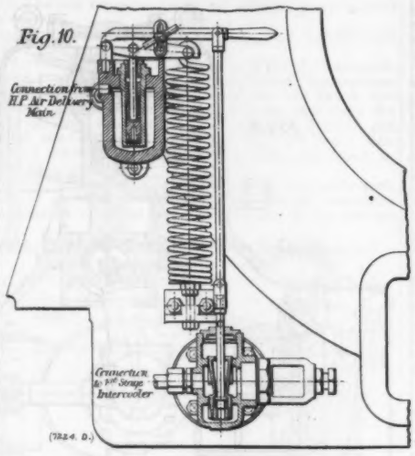
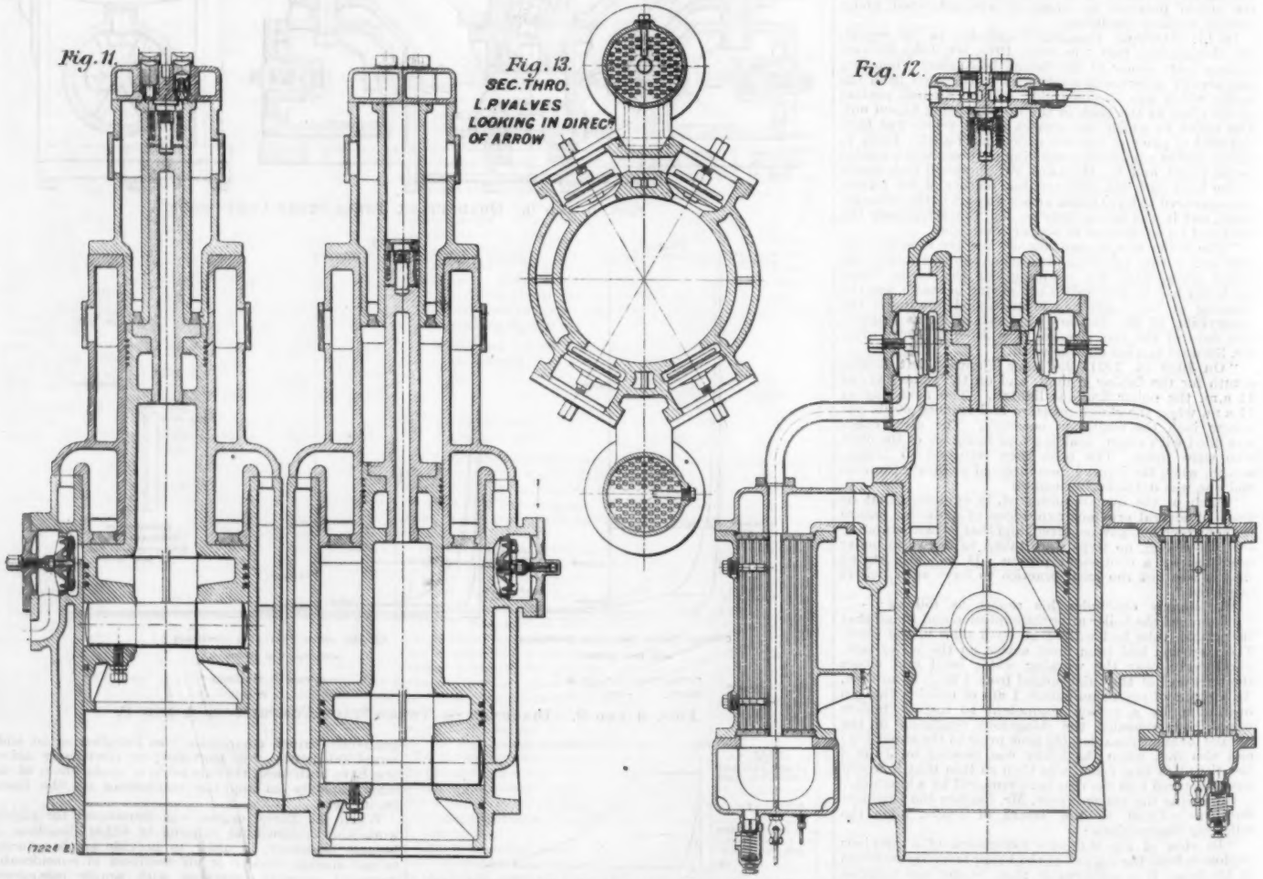


FIG. 10. AUTO-CONTROL GEAR FOR THREE-STAGE COMPRESSOR.

has the effect of overloading the high-pressure cylinder—if one may use the term—in the sense that the designed ratios of compression are altered and too many compressions thrown upon the high-pressure stage, with a consequently greater rise in temperature and a resultant risk of falling off in efficiency due to carbonisation of valves.

It is the practice of some builders to fit compressors of twice the capacity they consider actually required for injection. Fig. 7 shows the low-pressure diagram for such a compressor when delivering its full quantity of air, and when wire-drawn, after recharging starting bottles, to deliver the greatly reduced quantity required for injection. Figs. 8 and 9 show the diagrams of the low-pressure, intermediate-pressure and high-pressure cylinders combined, Fig. 8 being for a compressor of reduced size, working under the best conditions, and Fig. 9 being the compressor referred to of twice the size, running with wire-drawn inlet to low-pressure cylinder. The increased compressions and temperatures in all the cylinders, particularly the high-pressure cylinder, will be noted, and these conditions obtain all the time the vessel is under way at sea and until she reaches port, or probably 95 per cent. of her running time. Fig. 9 gives also a diagram in the corner which indicates the difference in the crosshead loads in the two machines of Figs. 8 and 9, showing that, apart from the greatly increased load in "B" at maximum output, the load when running at the reduced output equivalent to the compressor diagram "A," is still greater than that of "A." It is for this reason that the author referred, to the "steam" analogy in an earlier paragraph, as with two equally dissimilar steam engines, such an increase in total load would not be found, the loads, on the contrary, being reduced.

Various other methods of regulation have been suggested; for example, instead of wire-drawing the suction, the surplus air can be blown off from the first-stage intercooler drain. The effect on the succeeding stages is the same as in wire-drawing the suction, and it has the advantage that a relatively small regulating valve can



FIGS. 11, 12 AND 13. BEARDMORE-TOSI MAIN COMPRESSOR.

The author advances the view that the main compressor is usually made needlessly large, and that better efficiency in operation, together with a saving in first cost, weight, fore and aft length, and power, would be obtained if the capacity of the main compressors were reduced. He is aware that on entering narrow water the engines may be stopped or reversed at frequent intervals, and on each occasion manœuvring air will be required, but if the functions of the auxiliary and emergency compressors (which by Lloyd's Rules must be fitted) are reconsidered, he suggests that the replenishment of this air can be provided for by them. It will

under easier conditions and require less overhaul if it is running for a greater part of its life lightly loaded, and therefore that it can be of such a size as to deal amply with its maximum loads, however long; in other words, it is not detrimental to give it an ample margin in capacity.

A multi-stage compressor, on the other hand—if the same delivery pressure is maintained—usually has its output varied, with relation to the Diesel engine which drives it, and which it is supplying with injection air, by some form of wire-drawing on the suction of the low-pressure cylinder, and such method of regulation

be used. This method is adopted in the quadruplex three-stage compressor built for many years by the author's firm. In some marine compressors installed before the war, this regulation was carried out automatically, as in Fig. 10. In all compressors of the trunk piston type, it is better to regulate from the first stage intercooler, so as to avoid the risk of crank-case lubricant being sucked into the low-pressure cylinder, as is the case when the first-stage suction is wire-drawn.

During the discussion on the paper read by Professor Hawkes before this Institution last session, various methods of regulation of the delivery volume were

suggested, by interposing adjustable cylinder clearance in one or other of the cylinders. A study of this question shows that no such methods can be used to reduce the amount of air delivered without also wire-drawing the inlet air, or blowing off surplus air at one of the stages. Wire-drawing at the first-stage suction must obviously increase the total temperature range. The only way to utilise this "variable-clearance" principle, so as to vary the volume of air delivered without altering the stage pressure and temperatures, is to provide clearance regulation at each stage, an arrangement which, while theoretically correct, has practical drawbacks.

Another method which the author designed and used both in quadruplex and vertical compressors, is to provide an auxiliary low-pressure cylinder, having a volume of about one-third of the low-pressure cylinder, and which could be brought into action, by hand or automatically, whenever the working pressure fell owing to the starting bottles requiring replenishment. The compressor can be driven from the main engines by levers*; the top of the intermediate pressure cylinder is used as an auxiliary low-pressure cylinder in the manner described.

It will be seen, however, that none of these expedients are necessary if the duty of re-charging the starting bottles is performed by a separate machine. In that case, the size of the main compressor, and consequently the weight, cost and space, could be greatly reduced, and also the loads on its working parts. It would then be sufficient to provide the main compressor with a margin of say 15 per cent. above the actual requirements and it would always be working under the best conditions of temperture and load.

Under Lloyd's Rules, each vessel must carry an emergency compressor. This machine, somewhat increased in size, if necessary, could be started when the ship enters narrow waters, and it could be provided with an automatic unloading device, if desired, and would replenish any air used from the starting bottles under usual circumstances. Semi-Diesel engines of considerable power are readily started from a small starting bottle which can be quickly charged to the required pressure of 200 to 300 lbs. per square inch by a simple hand compressor, so that, in vessels of large power, any increase in the size of the emergency compressor can be readily made while still providing that this emergency set can be promptly started from cold. The auxiliary compressor is always in reserve also, and would itself be used for re-charging if special conditions made this desirable.

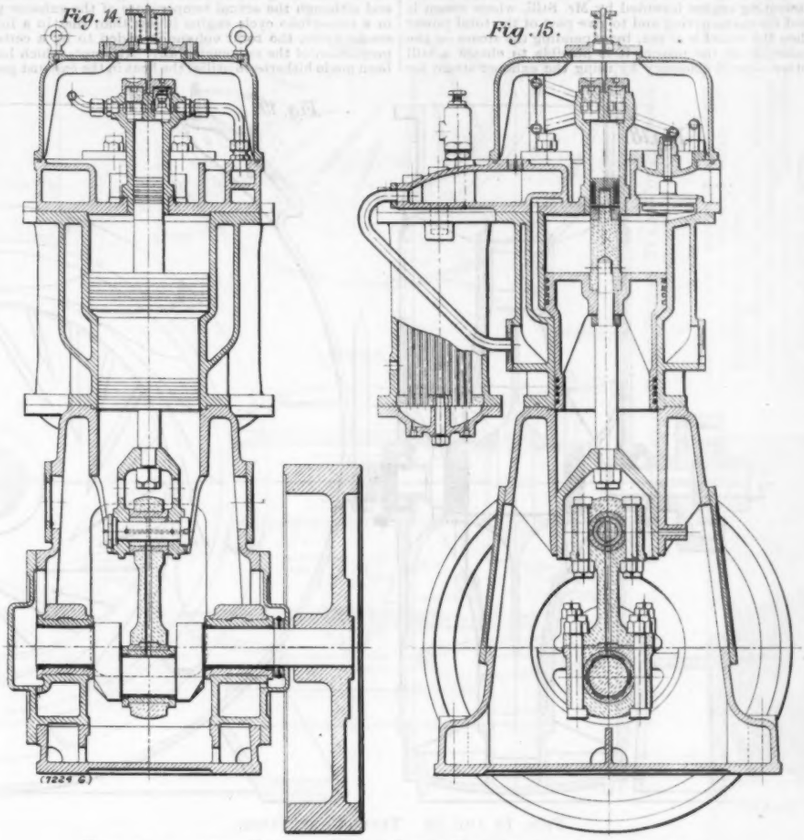
Auxiliary Compressors.—The primary function of the auxiliary compressor is to take the place of the main compressor, should the latter develop any defect; hence, under Lloyd's Rules it must be of the same size as the main compressor in a single-screw vessel, unless the main engines are capable of working with some of the cylinders out of action.

Its secondary use is to provide for rapid manœuvring where frequent reversals may be necessary in a short time. This secondary function, however, taken by itself, would not demand such a large compressor. It will be seen, therefore, that one advantage of the author's suggestion to reduce the capacity of main compressors is that the same saving of cost, weight and space would accrue in the auxiliary compressors, while the power required to drive these would be less. Whether driven by internal-combustion engines of the Diesel or semi-Diesel type, by steam or electric motor, the savings referred to would naturally affect this also, with a total gain which would be considerable. Taking as a rough approximation, that the power required for compressing the air for the main engine is 10 per cent. of the indicated horse-power of that engine, then sufficient power must be available, whether in an independent prime mover directly attached to the auxiliary compressor or in an auxiliary unit provided for general electric lighting and power supply in a vessel, for approximately one-tenth of the main engine power for driving the auxiliary compressor. Therefore, reductions of the space required, the weight and cost of this unit, are important matters.

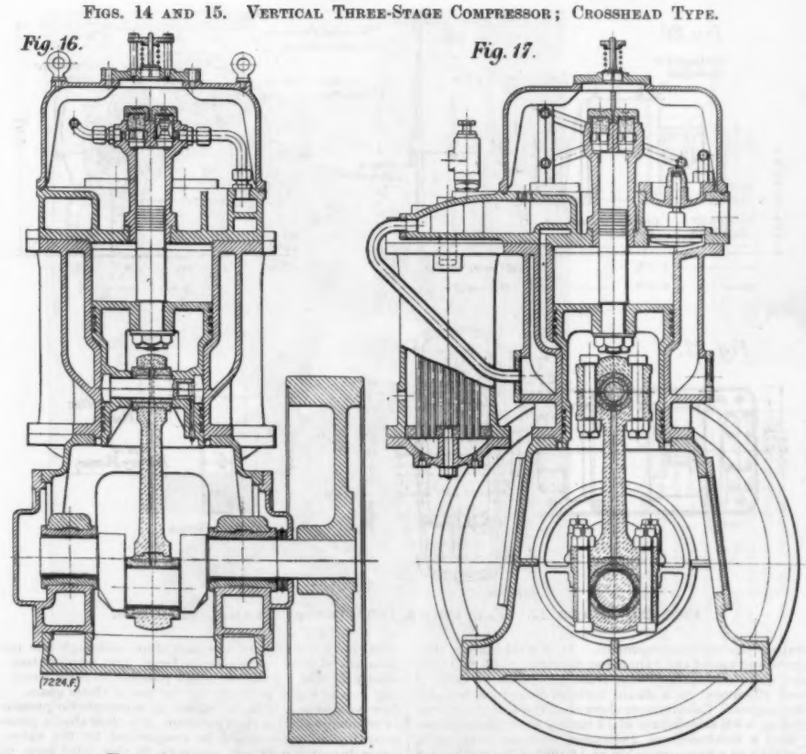
Modern practice in the construction of these auxiliary air compressors is in the direction of using totally enclosed, quick revolution machines, with a view to reducing the space and weight to a minimum. Properly designed suction and delivery valves will permit of satisfactory performances at speeds of 400 r.p.m. to 450 r.p.m., for continuous work, these speeds being to-day in common use in land work. Where the prime mover is a semi-Diesel engine, the speed of the auxiliary compressor is determined more by that of the prime mover than by exigencies of design in the compressor itself. The speeds mentioned present no difficulties for quick-revolution forced-lubrication machines so far as any of the working parts are concerned, these speeds having been common practice in steam generators for electric lighting sets for years past.

The most vital parts of the compressor are undoubtedly the valves, and divergent practice exists as to the arrangement of these so far as cooling is concerned. In the author's view it is of the highest importance that the whole of the valves should be thoroughly cooled, but complete cooling of valves—with their covers—entails a little longer time for inspection and overhaul than if the valves are so arranged as to be readily accessible from the outside of the compressor. Practically the only reason to-day for the frequent inspection of valves is the likelihood of carbonisation of these valves from the lubricant used. Carbonisation, however, is more likely to occur if the water-jacketing of the valves and covers is not complete; in practice, therefore, if ready inspection is insisted upon, it must be expected that such inspection will have to be more frequently carried out.

"Ready Access" valves are shown on the compressor, Figs. 11 to 13. These are of the "plate" valve type, and cannot in the ordinary sense be said to be jacketed at all. "Water-jacketed" valves are shown in the compressor, Figs. 14 and 15, the first, second and third stage valves, with their covers, being surrounded by the jacket water, which ensures a lower mean temperature of the valves with their springs. From the point of view of "access" the high-pressure valves in Figs. 14 and 15 are reached by swinging over the small cover carrying the jacket water relief valve, and draining off a little of the jacket water. The low and inter-



FIGS. 14 AND 15. VERTICAL THREE-STAGE COMPRESSOR; CROSSHEAD TYPE.



FIGS. 16 AND 17. VERTICAL THREE-STAGE COMPRESSOR; TRUNK TYPE.

* An arrangement of this kind was illustrated in ENGINEERING, vol. cii, Plate XL.

mediate pressure valves are inspected simply by removing the large cover surrounding the high-pressure cylinder, for which purpose eyebolts are provided. It would be observed that the auxiliary compressor in Figs. 14 and 15, which represents the latest practice of the author's firm, is provided with a crosshead at the top of the connecting rod to take the sideways thrust of the latter, and as the rings of the intermediate pressure piston are well above the crosshead, there is no likelihood of the crank-chamber lubricant finding its way into the compressor.

An alternative type which has been frequently used in the past is shown in Figs. 16 and 17, this type having a trunk piston. It makes a slightly lighter machine, requiring less head room, but it has the disadvantage that, as the connecting rod top end is placed between the low-pressure and the intermediate-pressure rings, there is more risk with this construction of oil finding its way into the compressor. Moreover, this type involves side thrust from the connecting rod being thrown on the intermediate cylinder, and in continued use, the crosshead type will undoubtedly give better service.

In auxiliary compressors the question of running for long periods at a reduced output need not be considered, as, when not required, they can be shut down; they can also be arranged for driving at variable speed, consequently it is better not to arrange these auxiliary machines with methods for throttling the suction inlet; and the proportions of the cylinder diameters, together with their clearances, can be so arranged as to obtain practically equal loads on the up and down stroke.

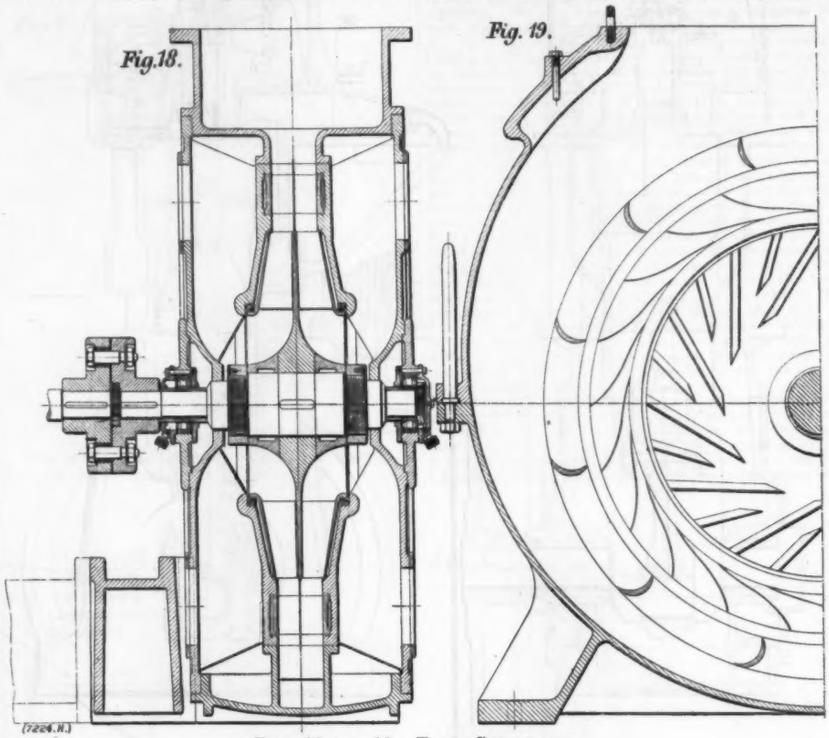
In vessels fitted with electrical auxiliaries, the auxiliary compressor is usually motor driven. Fig. 1, page 170, shows a single-crank machine of this type of a capacity of 180 c. ft. per minute. This machine is fitted with two independent intercoolers, one for the low pressure, and the other for the intermediate pressure delivered air. The intercoolers are very accessible. In vessels where the deck auxiliaries are driven by steam, the engine-room auxiliaries may require to be steam-driven also, and Fig. 2, page 170, shows a three-stage compressor with steam cylinder interposed between the air cylinders and the crank-case. The air cylinders are of the same construction as in the previous machines; the steam cylinder is provided with a piston valve and shaft governor as in high-speed engine design. Fig. 3, page 170, shows a small auxiliary or emergency compressor unit of a capacity of 8 c. ft. per minute, compressing to 1,000 lb. pressure, the prime mover being direct coupled, of the two-stroke type and using paraffin fuel. Fig. 4, page 170, shows a larger unit of 7 b.h.p., having a capacity of 15 c. ft. per minute, driven by a solid injection heavy oil engine.

Solid-Injection Diesel Engines.—With this type of marine Diesel engine, there is no definite rule fixed by Lloyd's Survey to determine the exact size of auxiliary compressor which shall be fitted for supplying air for manœuvring purposes. Lloyd's Rules, however, as to the capacity required in the starting bottles, furnish some guide, it being necessary to supply air for twelve separate starts, and the exact size selected depends upon the time which may be allowed by the builders to raise the pressure in the manœuvring bottles to the maximum pressure. The pressure which is considered necessary for manœuvring varies a little in the practice of builders of this type of engine, and under some conditions compressors of the two-stage construction can be satisfactorily used with such engines.

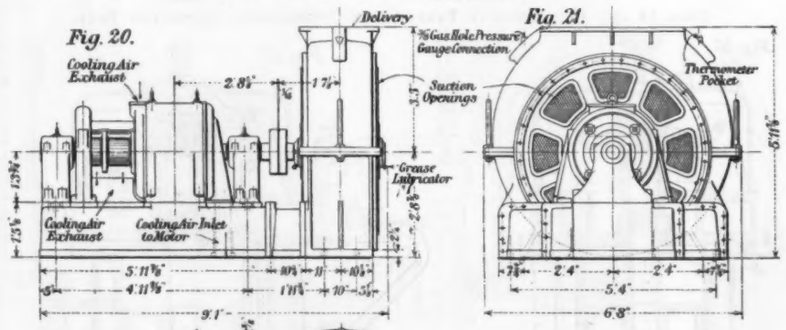
Air for Scavenging Purposes.—In two-stroke cycle engines, a further air compressor is needed in the form of a scavenger pump. It has been the practice to provide this in line with, and as part of, the engine itself disposing the scavenge pump in such a way as to supply the requisite air in as direct a way as possible from the delivery valves of the scavenge pump to the scavenging valves in the engine cylinder.

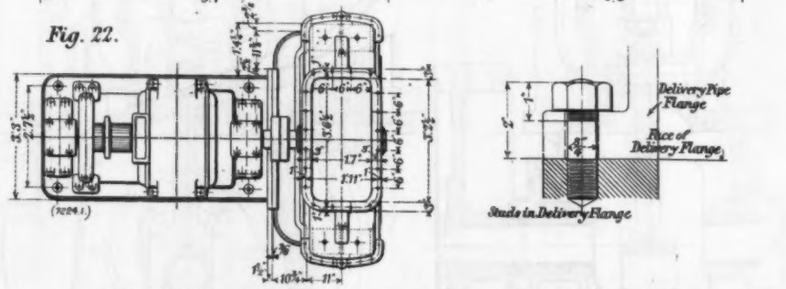
It has always been recognised by engineers that the mechanical efficiency of a large, double-acting, reciprocating compressor must necessarily be somewhat low, and probably Messrs. Sulzers, of Winterthur, were the first to adopt the practice of obtaining their scavenging air from an independently driven compressor or blower of the centrifugal type. With the reduced scavenging pressures, now adopted, it is obvious that the centrifugal principle offers still more advantages, from the point of view of mechanical efficiency and therefore of the power required to provide the scavenging air, and during the last ten years the scavenging pressure has been successively reduced from about 5 lb., &c., to about 2 lb. per square inch. The reduction in the weight and overall length of the two-stroke cycle engine when piston scavenging pumps are replaced by blowers on the centrifugal principle, is very marked. Figs. 18 and 19 show a centrifugal or turbo-blower type constructed by the author's firm, capable of providing scavenging air for a two-stroke cycle engine of 4,000 i.h.p., while Figs. 20, 21 and 22 show the general arrangement of this machine with its high-speed, continuous-current motor, the combined plant running at 3,000 revolutions. The small overall dimensions of the unit will be observed. The difficulty of readily obtaining continuous-current motors of the necessary high speed for direct coupling frequently leads to the intervention of gears between the motor and compressor, and Fig. 23 shows a turbo-scavenging pump of 3,500 cub. ft. capacity driven by a slow-speed motor in such a manner. Modern improvements in turbo-compressor practice enable these machines to be efficiently constructed for relatively small sizes, and Figs. 24 and 25 show a turbo-compressor set of 1,500 cub. ft. to 2,000 cub. ft. capacity per minute at 2 to 3 lb. pressure, direct coupled to a small, high-speed motor of 45 h.p.

These motor-driven turbo-scavenging pumps can be readily arranged for considerable variation of speed, volume and pressure, by rheostatic control. Where the engine-room auxiliaries are intended to be operated by steam, as discussed earlier under the heading of "Auxiliary Compressors," the turbo-scavenging pump can be driven by a steam turbine (Fig. 26). When exhausting into a condenser with a high vacuum, the steam consumption of such a unit would be very low. Indeed, in the interesting engine invented by Mr. Still, where steam is used for manœuvring and to give part of the total power when the vessel is at sea, by expanding the steam on the underside of the piston, it is possible to obtain a still better overall efficiency by using the exhaust steam for scavenging pump steam driven, by utilising the heat available in the exhaust gases for raising the steam required. The large amount of heat which passes away in the exhaust gases of a Diesel engine is well known, and although the actual temperature of the exhaust gas in a two-stroke cycle engine is less than that in a four-stroke cycle, the total volume is added to by a certain proportion of the scavenging air. Attempts which have been made hitherto to utilise the heat in the exhaust gases



FIGS. 18 AND 19. TURBO-COMPRESSOR.





FIGS. 20, 21 AND 22. ELEVATIONS AND PLAN OF TURBO-COMPRESSOR.

operating the turbo-compressor. It is well known that the extreme toe of the expansion diagram could be made use of more advantageously, from the point of view of overall efficiency, in a steam turbine than in a reciprocating engine. Calculations show that the steam turbine, operating with inlet steam at 18 inches vacuum, exhausting into a condenser at 28 inches vacuum, and using the weight of steam available at 18 inches from the Still engine, will be sufficient to drive a turbo-scavenging pump of the capacity required.

It is not outside the realm of possibility that the two-stroke cycle engine of the future may have its turbo-have been limited by the fact that, although the total amount of heat available is large, the temperature is relatively low, so that it is not possible to raise steam to any considerable pressure by the use of these gases. If, however, steam is to be raised at atmospheric pressure, or somewhat below that pressure, it is clear that a greater quantity of water could be evaporated by the exhaust gases because a larger quantity of the total heat discharged to atmosphere in this case is available for the production of low-pressure steam. Developments in turbo-scavenging, including placing the scavenging pump on a platform level with the engine cylinders, so as to get

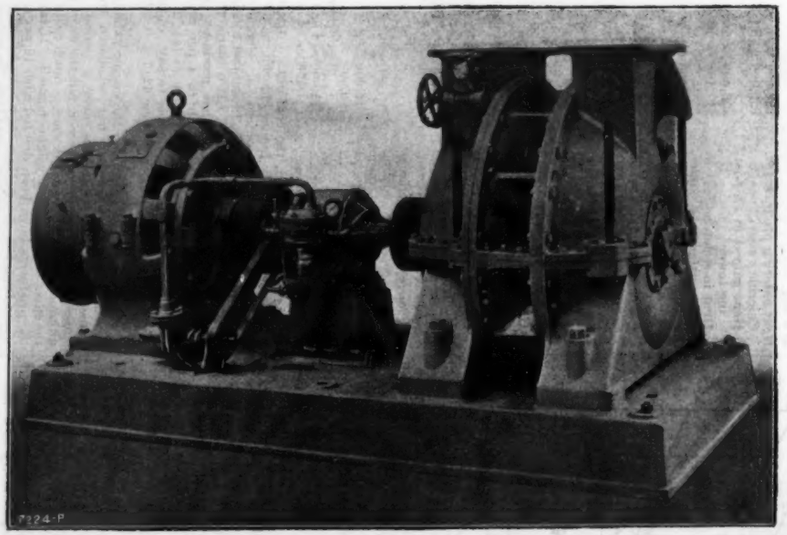
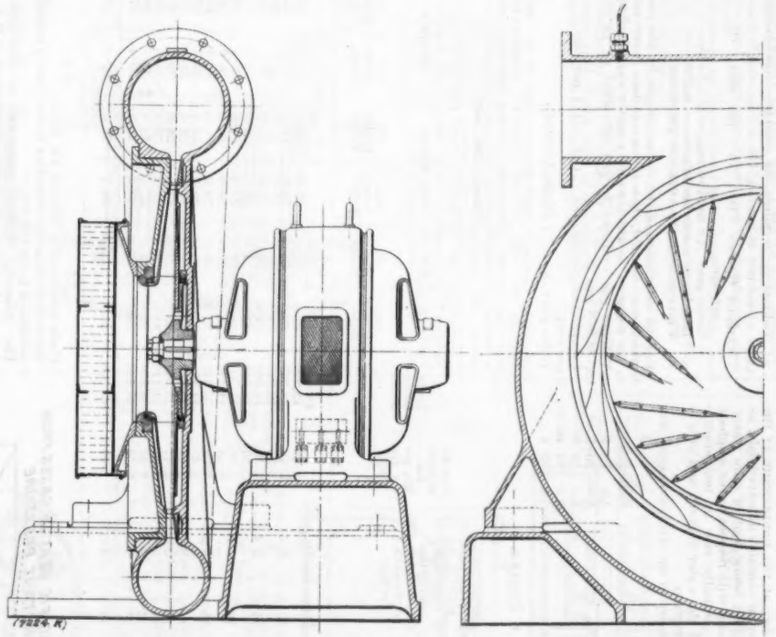


FIG. 23. GEAR-DRIVEN TURBO-COMPRESSOR.



FIGS. 24 AND 25. OVERHUNG-TYPE OF MOTOR-DRIVEN TURBO-COMPRESSOR.

as straight a flow of air to them as possible, the reduction of air friction and eddy losses in the scavenge air passages and ports of the cylinders, and further reductions in air-scavenging pressures even below that of 2 lb. per square inch, which modern practice has proved satisfactory, will all tend to reduce the actual horse-power required to drive the turbo-compressor itself. The two-stroke cycle engine of the future, therefore, may have its scavenging turbo-compressor driven by a steam turbine, the steam for which is provided from the heat at present rejected with the exhaust gases.

For coastal craft, or similar vessels in which it is desired to utilise only one source of power, and that the internal-combustion engine, compressed air can be efficiently used for steering gears, winches, &c., if the rule is observed that, other things being equal, the highest all-round efficiency will be obtained by using low pressures of, say, 20 or 25 lb. or thereabouts, instead of the usual deck pressures of 80 to 100 lb.

No attempt should be made to utilise air expansively, the saving being made at the other end, namely, by reducing the power required to compress the air owing to using it at low pressure. In such auxiliaries, therefore, the air would be used as steam is used now, but with a very late cut-off and practically no expansion; and under such conditions experience has shown that no fears need be anticipated of troubles through freezing at the exhaust in wintry weather.

The author wishes to thank the many firms who have courteously supplied him with information, and desires also to acknowledge the great assistance he has received from members of his staff in the preparation of this paper.

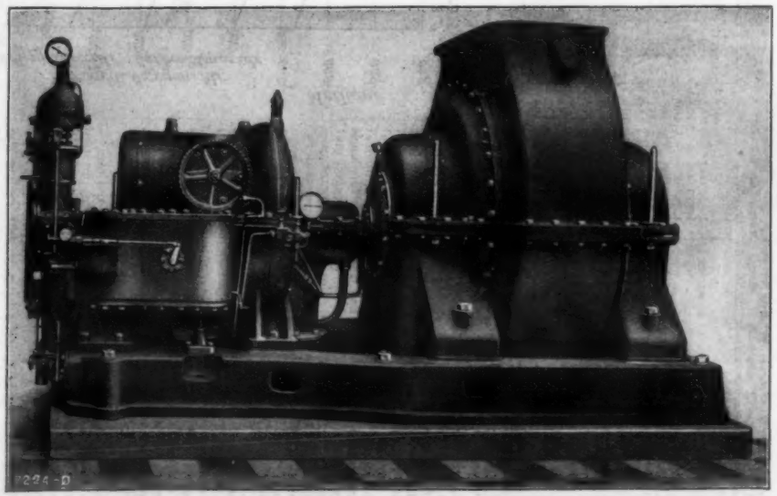


FIG. 26. TURBO-SCAVENGING PUMP DRIVEN BY STEAM TURBINES.

CATALOGUES.

Motors.—Messrs. Higgs Brothers, Sand Pits, Birmingham, send the January issue of their monthly stock list of electric motors containing particulars of machines ready for delivery.

Lifts.—An eight-page catalogue illustrating some of the passenger, goods, service and motor-car lifts made by them comes from Medways Safety Lift Co., Limited, 2, Bucklersbury, London, E.C. 4.

Lifts.—Messrs. R. A. Evans, Limited, Prospect-road, Leicester, send a well-arranged catalogue of parts and accessories for electric lifts. Tables of prices, net weights and shipping weights, are given.

Transformers.—A pamphlet containing notes, specifications and descriptive particulars of some of their transformers has been received from Messrs. Johnson and Phillips, Limited, Charlton, London, S.E. 7.

Tractor Cranes.—A jib crane mounted on a truck with four broad tractor wheels or a caterpillar tractor is described in a catalogue received from the Industrial Works Company, Bay City, Michigan, U.S.A.

Ball and Roller Bearings.—A pamphlet explaining the advantages of ball and roller bearings, especially for colliery machinery and vehicles, comes from the Hoffman Manufacturing Company, Limited, Chelmsford.

Forced Draught Furnaces.—The construction of forced draught furnaces and of the various parts are illustrated and described in a catalogue received from Messrs. Meldrums, Limited, Timperley, near Manchester.

Aluminium.—A catalogue of aluminium mats, sheets and extruded bars of commonly useful sections comes from British Insulated and Helsby Cables, Limited, Prescot, Lancashire. The company also rolls thin copper sheets.

Files.—An interesting pamphlet relating to files illustrating many shapes and giving an account of the method of cutting and hardening employed in their manufacture has been issued by Messrs. Edgar Allen and Co., Limited, Sheffield.

SOME OBSERVATIONS ON A PRODUCER-GAS POWER PLANT.*

By H. S. DENNY, C.B.E., and N. V. S. KNIBBS, B.Sc., of London.

(*Concluded from page* 154.)

APPENDIX II.

Specific Heat of Gases at Constant Pressure.—Fig. 10 furnishes curves for the mean specific heats between 0 deg. and temperatures up to 1,200 deg. C. of the constituents of producer-gas and the products of its combustion. It has been usual in technical investigations to employ the general formulæ given by Le Chatelier for the permanent gases and for water vapour and carbon dioxide, but this procedure is no longer justified since the more accurate determinations of Holborn and Henning and others are available.

The nitrogen, carbon dioxide, and water vapour curves are constructed from Holborn and Henning's figures, and are probably the most accurate of all the curves. Their figures for water vapour are mean specific heats from 100 deg., but for the purpose of the curves these have been reduced to 0 deg. In so doing a slight error is probably introduced, but it cannot be considerable. Carbon monoxide is assumed to be identical with nitrogen, and the similarity of its other physical properties justifies the belief that the assumption leads to only very slight error. The data for air, oxygen and hydrogen are less accurate at elevated temperatures, but the curves have been constructed after a consideration of all that were available. There seems to have been only two determinations of the specific heat of methane: that of Regnault, 0·593, and that of Lussana, 0·591. These figures are considerably higher than that calculated from Le Chatelier's molecular heat formula: $6{\cdot}5 \times 0{\cdot}0006$ T, but a divergence would be expected from the fact that the molecule contains five atoms. The agreement between the two determinations justifies their adoption at ordinary temperatures, and in the absence of any data the increase with rise of temperature has been assumed to be the same as that of nitrogen. Probably it is greater, but in any case the third figure in the specific heat of this gas is of no significance.

Calculation of the Available Heat in the Air and Gas.—In the calculation of heat balance, &c., the usual practice seems to have been to consider the sensible heat in a gas as that required to heat it from 0 deg. C. up to the existing temperature, and the latent heat as that evolved in the condensation of all the water vapour carried by it. The procedure is quite arbitrary, but it has the advantage of simplicity and it leads to results very nearly the same as would be obtained by any other. Nevertheless, it is more rational to calculate the heat actually available in the gases, and this had been done in the calculations made in connection with the heat balance.

The heat which is available (*i.e.*, which thermodynamically is capable of being transformed into work) is that evolved in cooling the gases down to atmospheric temperature, and the latter during the test week was 11·5 deg. C. (mean atmospheric temperature). The available sensible heat is considered as the amount evolved in cooling the gases without condensation down to 11·5 deg., whilst the available latent heat is considered as that evolved by condensation at 11·5 deg. of the water vapour carried in excess of the saturation quantity at that temperature. Actually this water vapour would condense continuously between the saturation temperature and 11·5 deg., but the procedure indicated above merely leads to a slightly higher latent heat figure at the expense of the sensible heat, the total available heat being the same. At 11·5 deg. the latent heat was taken to be 590.

In calculating the heat in the gases at various points in the plant, the water vapour content must be known. That of the air entering the producers is given by the saturation temperature, the volume of the air itself being, of course, calculated from that of the gas produced by a comparison of the percentage of nitrogen in each. The water vapour in the gas leaving the producers was obtained by deducting the amount decomposed in the latter, calculated from the gas and coal composition, &c. After the gas passes through the washer its water vapour pressure is assumed to be that of the liquor in the washer at the temperature of the issuing gas. Since the liquor contains dissolved salt, its vapour pressure is depressed below that of pure water. The same assumption is made with respect to the sulphate tower. Here the gases actually rise in temperature owing to condensation of the water vapour, and also in part to the heat of the reaction.

The following is a summary of the data, averaged over the test week:—

Temperatures—		Deg. C.
Atmosphere	Air	11·5
Inlet air tower	Air	26·5
Outlet air tower	Air	71·9
Inlet superheater	Air	85·48
Outlet superheater	Air	179·8

Calorific value (per cub. ft. saturated at 15 deg.)

	C.H.U.	B.Th.U.	Cal.
Net ...	69·9	126	31·8
Gross ...	78·4	141	35·6

Volume air required for complete combustion of 1 volume of gas: 1·11.

Exhaust Gases: CO_2: 15·2 per cent., O_2: 2·9 per cent.

Ratio gas: Air used in engines 1: 1·35.

Line hours worked on engines = 6,376.

Units generated = 975,000 kw.-hours.

For the calculation of the volume of gas by the piston displacement method, the following data were taken on No. 6 engine, to which a rotary meter was attached.

Volume gas (reduced to gas saturated at 15 deg): 18,188,000 cub. ft.

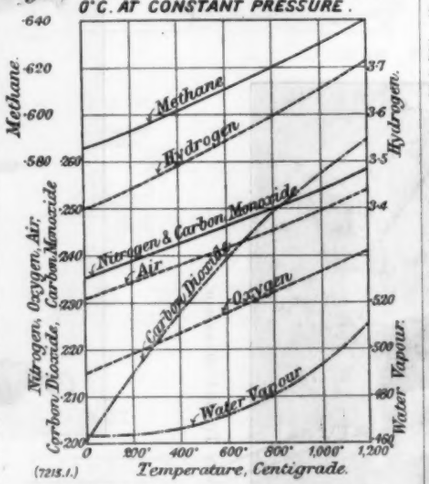
Composition of exhaust: CO_2: 14·4 per cent.; O_2: 3 per cent.

Ratio gas: Air: 1: 1·40.

No. 6 ENGINE.

Date.	Time.	Vol. Gas Used, Reduced to Gas Saturated at 15 deg. and 760.	B.Th.U. in Gas Used. (Multiplied by 1,000,000).		Temp. Leaving Cylinders.	Composition of the Cold Gases by Analysis. Per Cent.		Gas-Air Mixture. Vol. Mix per Vol. Gas Used.	Units Generated.	Efficiency Per Cent.					
										1 On E.H.P.		2 On B.H.P.		3 On I.H.P.	
			On Lower Value.	On Higher Value.						On Lower Value.	On Higher Value.	On Lower Value.	On Higher Value.	On Lower Value.	On Higher Value.
			Lower.	Higher.	Deg. C.	CO_2.	O_2.		kw.-hr.						
9th	6 a.m.–6 p.m.	1,355,000	164	183	—	—	—	2·48	12,220	25·4	22·8	27·3	24·5	32·1	28·8
	6 p.m.–6 a.m.	1,339,000	174	194	483	15·5	2·5	2·42	11,360	22·3	20·1	24·0	21·5	28·2	25·4
10th	6 a.m.–6 p.m.	1,298,000	160	178	480	—	—	2·36	12,010	25·6	23·1	27·5	24·8	32·4	29·2
	6 p.m.–6 a.m.	1,298,000	160	179	486	14·6	2·4	2·30	11,680	25·0	22·3	26·8	24·0	31·5	28·1
11th	6 a.m.–6 p.m.	1,277,000	144	160	483	—	—	2·30	11,640	27·6	24·8	29·7	26·5	34·8	31·3
	6 p.m.–6 a.m.	1,297,000	156	173	491	16·5	2·5	2·30	11,700	25·6	23·1	27·5	24·8	32·4	29·2
12th	6 a.m.–6 p.m.	1,315,000	166	185	513	—	—	2·30	11,780	24·3	21·7	26·0	23·3	30·6	27·4
	6 p.m.–6 a.m.	1,360,000	174	196	510	15·3	2·2	2·25	11,510	22·5	20·2	24·2	21·6	28·5	25·4
13th	6 a.m.–6 p.m.	1,332,000	170	191	504	—	—	2·35	11,720	23·5	20·9	25·3	22·5	29·8	26·5
	6 p.m.–6 a.m.	1,348,000	174	194	513	13·4	2·6	2·45	11,460	22·5	20·2	24·2	21·6	28·5	25·4
14th	6 a.m.–6 p.m.	1,230,000	155	174	498	14·6	3·4	2·47	11,660	25·6	22·9	27·5	24·6	32·4	28·9
	6 p.m.–6 a.m.	1,214,000	163	182	492	14·1	3·1	2·49	11,140	23·3	20·9	25·1	22·5	29·5	26·5
15th	6 a.m.–6 p.m.	1,265,000	154	173	497	12·6	4·1	2·52	11,570	25·6	22·9	27·5	24·6	32·4	28·9
	6 p.m.–6 a.m.	1,260,000	166	185	507	13·4	4·6	2·58	11,680	24·1	21·6	25·9	23·2	30·4	27·3
Totals	and averages for week	18,188,000	2,280	2,546	497	14·4	3·0	2·40	163,100	24·4	21·9	26·2	23·5	30·9	27·7

Fig. 10. MEAN SPECIFIC HEAT OF GASES FROM 0°C. AT CONSTANT PRESSURE.



(7218.1.)

Inlet producers	Air	201·3
Leaving producers	Gas	568·4
Leaving superheaters	Gas	465·2
Entering washer	Gas	385·7
Leaving washer...	Gas	87·0
Entering sulphate tower ...	Gas	82·7
Leaving sulphate tower ...	Gas	84·0
Leaving No. 1 gas tower ...	Gas	72·0
Leaving No. 2 gas tower ...	Gas	52·7
Entering fans	Gas	50·4
Entering condenser	Gas	49·1
Entering scrubbers	Gas	29·8
Leaving scrubbers	Gas	27·1
Entering power-house	Gas	27·0
Engine exhaust	Gas	497·0
Atmospheric pressure	Gas	752 mm.
Gas entering power house ...	Gas	758 mm.

Coal—

Gasified		913 tons
Burnt under boilers		242 tons
Calorific value	12,550 B.Th.U.	6,970 C.H.U.

Gas—

Volume produced: 118,700,000 cub. ft. saturated at 15 deg., 110,600,000 cub. ft. dry at 0 deg.

Composition: CO_2: 14·9 per cent., CO: 10 per cent., H_2: 24·2 per cent. CH_4: 3·1 per cent., N_2: 27·8 per cent.

Units generated: 163,100 kw.-hours.

From these data the correction factor *t* (see Appendix I) is calculated to be 123 deg. C.

The following thermal quantities at the different points in the producer plant are given in C.H.Us. of available heat per 1,000 cub. ft. of dry producer-gas at 0 deg.:—

Heat entering producers ...	159,500 C.H.U.	
Calorific value of coal ...	129,000 =	80·9 per cent.
Heat gained in air-heating tower	9,600 =	6·0 per cent.
Heat in steam added ...	17,100 =	10·7 per cent.
Heat gained in superheaters	2,900 =	1·8 per cent.
Heat in gas leaving producers...	129,000	
Calorific value of gas ...	84,100 gross	
	75,000 net.	
Loss of heat in producers	30,500 =	19·1 per cent.
Loss of heat in superheaters	4,200 =	2·6 per cent.
Efficiency of heat exchange in superheaters:—		
Heat lost by gas ...	4,200	
Heat gained by air ...	2,900	
Efficiency ...	69 per cent.	
Loss between superheaters and washers	3,200 =	2·0 per cent.
Loss in washers	3,800 =	2·4 per cent.
Loss in sulphate tower ...	4,300 =	2·7 per cent.
Loss in No. 1 gas tower ...	12,900 =	8·1 per cent.
Efficiency of heat exchange between gas cooling and air-heating towers:—		
Heat loss by gas ...	12,900	
Heat gained by air ...	9,600	
Efficiency	74 per cent.	
Loss in No. 2 gas tower ...	11,000 =	6·9 per cent.
Loss in gas cleaning plant	4,400 =	2·8 per cent.

As already mentioned, the coal used in the test week may have had a slightly higher calorific value than the figure taken. The distribution of weight between producers and boilers may also be subject to slight error, say, 2 per cent. as a maximum. It is therefore possible, but by no means probable, that producer efficiencies (*c*) and (*e*) may actually be up to 4 per cent. higher than the figures given, and efficiencies (*a*), (*b*) and (*d*), up to, say, 2 per cent.; that is to say, efficiency (*a*), for instance, might conceivably be $42{\cdot}7 + 0{\cdot}020 \times 42{\cdot}7 = 43{\cdot}6$ per cent.

The amount of steam from the engine exhaust boilers was not measured directly but calculated from their known average performance over a period. It may consequently be subject to error, but the error would be unimportant, and even if it were as much as 10 per cent. the effect on the efficiency figure is small. If, for example, the producers have been debited with 10 per cent. more steam from this source than they have actually received, efficiency (*a*), corrected, would be increased only to 43·9 per cent. The table given above furnishes full data for No. 6 engine.

* Paper read before the North-Western Branch of the Institution of Mechanical Engineers, at Manchester, on January 24, 1922. See Errata, page 169.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS

170,128. T. R. Cave-Browne-Cave, London. Epicyclic Toothed Gearing. (2 *Figs.*) July 22, 1920.—The invention relates to mechanical gearing, particularly suitable for use in connection with aircraft propellers driven by internal-combustion engines. The epicyclic reduction gear comprises three planet spur wheels 3 arranged between and meshing with a sun spur wheel 4 and a toothed annulus wheel 5. The sun wheel is mounted fast on the crankshaft 6, the annulus wheel 5 is mounted fast in the propeller boss 7, and the planet wheels 3 are supported by bolts 9, which extend across a lantern wheel 10 and secure

Fig. 1.

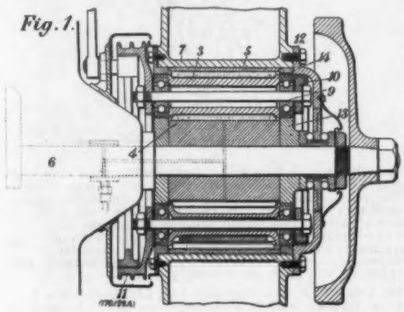
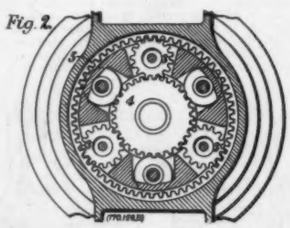


Fig. 2.



the same to a brake drum 11. The planet wheels 3 are made with hollow body parts and with enlarged plain ends 12, which are made fast to the outer races of the ball bearings; the sun wheel 4 is made with enlarged ends 13; and the annulus wheel is made with reduced plain ends 14. The outer peripheries of the ends 12 are of the same diameter as the pitch line of the planet wheels; the outer peripheries of the ends 13 are of the same diameter as the pitch line of the sun wheel; and the ends 14 are of the same diameter as the pitch line of the annulus wheel; consequently the ends 12 roll on and between the ends 13 and the ends 14 and centralise the parts. (*Accepted October* 26, 1921.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

169,633. C. D. Bascombe, Colchester. Internal-Combustion Engines. (3 *Figs.*) October 21, 1920.—To supply additional air to the induction pipes of internal-combustion engines an additional air inlet element is disposed between the throttle and the engine cylinder, and comprises a series of radial passages all leading from a single conduit to the engine intake pipe, such conduit conducting air to the radial passages from a point in the vicinity of the steering wheel, at which point the admission of

Fig. 1.

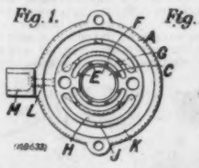
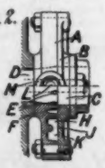


Fig. 2.



air to the conduit is controlled by means of a valve under the direct control of the driver. The elements A, B are bored with a central hole C, which constitutes part of the engine intake pipe D. From the hole C radial passages E lead to an annular slot F. Passages G lead from this slot F to another annular slot H, and yet another set J leads to the last annular slot K. A passage L leads from this slot K to the conduit M, in which the supply of air is regulated by a valve not shown in the drawings. (*Sealed.*)

LIFTING AND HAULING APPLIANCES.

169,744. W. H. Scott, Norwich. Electrically-Driven Winches. (2 *Figs.*) May 5, 1920.—A winch in accordance with this invention, has, for the shaft 3 carrying the bollards 1, or a winding drum 2 (or both), bearings 9a, 9b at, or towards, each end to ensure proper alignment of the shaft, which is driven by a worm-wheel 5 and worm 4a, the worm wheel 5 being keyed to the shaft 3 and the worm 4a being secured to, or formed on, a spindle 4, which also carries the armature 6 of the electric motor. The field magnets 7 are secured to the flanges of a casing con-

Fig. 1.

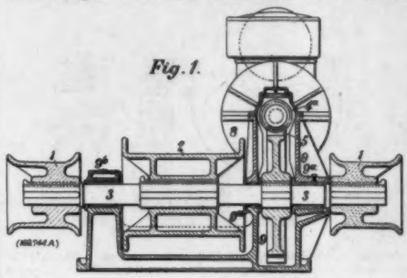
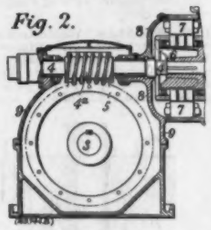


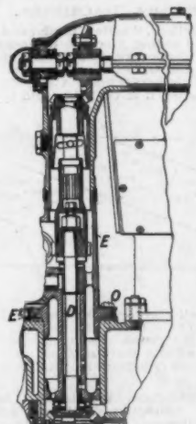
Fig. 2.



nected to the projecting part 8 from the gear-box 9, which gear-box extends from the base of the apparatus and carries the bearings 9a, 9a for one end of the shaft 3, which, at its outer end, is supported by the bearing 9b upon an extension from the base of the apparatus. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

169,555. Bentley Motors, Limited, London, and F. T. Burgess, London. Mountings for Shafts and Gear Wheels. (1 *Fig.*) July 14, 1920.—This invention has for its object to provide a mounting wherein a shaft or wheel can be delicately adjusted endwise, as, for example, to vary the mesh of a pair of bevel gears. According to this invention, a flange E2 on the outside of, and integral with, a sleeve E, in which the shaft D is



located endwise in bearings, is secured to a face by bolts or studs, and an abutment ring O is screwed on the flange E2 and adapted to bear upon the face. By screwing the ring O up or down, the height of the flange E2 from the face may be varied and the endwise position of the shaft adjusted. When the required position is obtained, the bolts are screwed up and the abutment ring bears hard on the face, and holds the flange clear therefrom. (*Sealed.*)

MINING, METALLURGY AND METAL-WORKING.

169,550. A. G. Strathern, Glasgow. Colliery Tram Shackles. (2 *Figs.*) July 10, 1920.—In a shackle for coupling together colliery trams or tubs of the type comprising two plate

Fig. 1.

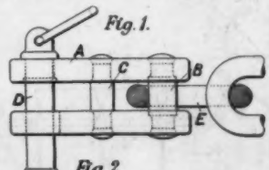
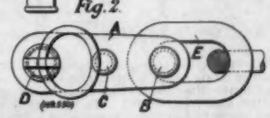


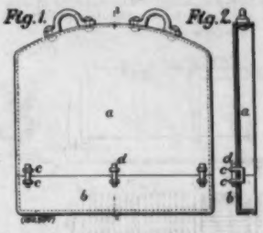
Fig. 2.



members spaced apart by a distance piece or distance pieces, and united by a rivet or bolt, the feature of the present invention consists in that the plate members are united by two studs formed integrally with shoulders which keep the plates at a predetermined distance apart, the said studs or distance pieces being riveted or welded or otherwise secured to the plate members. A, A are the plate members; B is the outer stud formed with shoulders and engaging with the chain link E; C is the inner stud, also formed with shoulders and serving to prevent relative movement of the plate members; D is the draw pin. (*Sealed.*)

169,597. W. P. Wrightson, Cardiff. Furnace Doors. (4 *Figs.*) August 18, 1920.—To facilitate the renewal of the lower portions of the door of certain kinds of furnaces for the treatment of iron and steel, which portions almost invariably are burnt

Fig. 1. *Fig. 2.*



away whilst the upper portions remain intact and serviceable, the door is divided into two portions *a*, *b* which are united rigidly in the same plane by U-shaped shackles *c*, the limbs of which pass through suitably aligned holes in the two portions and are secured by cottars *d*. (*Sealed.*)

MOTOR ROAD VEHICLES.

168,770. John Fowler and Co. (Leeds), Limited, Leeds, and H. Hodgson, Leeds. Endless Tracks. (5 *Figs.*) August 17, 1920.—This invention relates to endless tracks for vehicles, such as tractors, of that type which include a number of gripping shoes, plates or equivalents *b* strung together on a continuous rope *a* by means of clips located within the shoes, and the invention consists primarily in a construction of shoe and clip whereby the shoes are capable of transverse turning movements about the axis of the rope to permit the shoes to adjust themselves to the inequalities of ground surface without

Fig. 1.

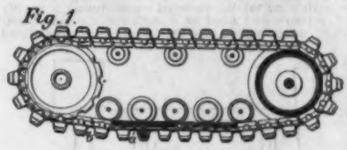
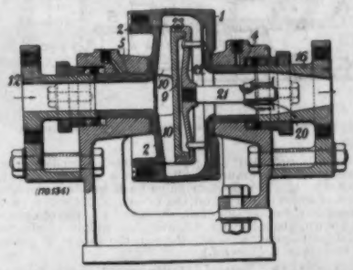


Fig. 2.

placing any torsional stress on the rope or the remainder of the track. The shoes *b* are in the form of hollow steel forgings, the outer parts of which are filled with wood *b1* and the exterior surfaces of which have angular gripping plates *b2*. Each shoe also comprises a separate, narrower inner part *b3* secured to the outer part by bolts and provided with a curved face for passage of the rope *a*, said inner part being provided with interior projections *b5* forming a seating to receive loosely the central circular part *c1* of a rope clip *c*. Each clip is formed in two parts connected together by screws or bolts passing through lugs. (*Sealed.*)

PUMPS.

170,134. J. Little, Felling-on-Tyne. Centrifugal Pumps. (3 *Figs.*) July 26, 1920.—This invention relates to centrifugal pumps of the kind having axially-arranged suction and delivery ports and an interiorly-bladed rotating casing to operate as an impeller to force liquid into a chamber in communication with a delivery port. The invention is characterised in that a fixed diffusion chamber is arranged to one side of the impeller and that an annular chamber is formed in the casing and around the outer periphery of the impeller and the diffusion chamber so that fluid will be transferred from the suction side of the pump to the pressure side without shock and without leakage taking place. The casing of the pump is formed in two portions 1, 2, which are formed with hollow extensions 4, 5. The portion 2 is

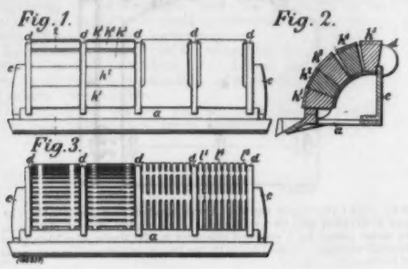


provided with a spaced plate 9, between which and the side wall of the portion 2 is a plurality of impeller blades 10. 12 is the suction pipe and 16 is the delivery pipe. The delivery pipe 16 is formed interiorly with a spider 20, in which is secured a shaft 21 on the inner end of which is secured a plate 22 provided with a flange 23 in which the plate 9 rotates. To the plate 22 is secured a plate, which is spaced from the plate 22 by shouldered rivets, the space between the plates providing a diffusion chamber. In operation, the fluid is drawn into the suction pipe 12 and into the impeller; the fluid then passes out of the impeller into the diffusion space and thus to the delivery end of the pump. The water leaves the impeller at a high velocity and gradually loses it without shock as it enters the diffusion chamber, a further rise

in the pressure head being gained in the diffusion chamber, and the fluid finally leaves the delivery end of the pump. (*Accepted October 26, 1921.*)

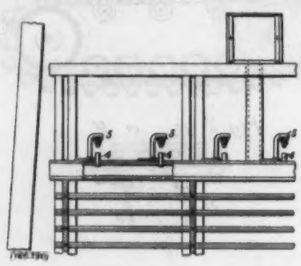
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

166,957. A. Jobling, Ilford. Furnace Firebricks. (6 *Figs.*) April 23, 1920.—This invention provides improved means for retaining the auxiliary firebars designed to combine with the firebridge proper in such a way as to permit of the employment of either firebricks or firebars without sacrificing the air spaces necessary to efficient combustion and designed also so as to enable replacement of burnt-out or otherwise damaged firebars to be effected with great facility and expedition. Accord-



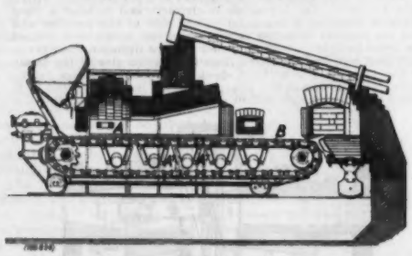
ing to this invention, a firebridge comprises curved retaining members *d* which interlock with the back bearer *a* and bridge plate *c*, and are spaced at intervals between firebrick segments h^1, h^2, h^3, h^4, h^5, or groups of curved firebars *l*, *l*, which are fitted tightly between each pair of retaining members. The retaining members *d* are constructed with laterally-projecting ribs upon which the margins of firebrick segments or firebars rest. (*Sealed.*)

166,790. F. E. Gill, Shipley, and The Davenport Engineering Company, Limited, Bradford. Cooling Towers. (4 *Figs.*) May 31, 1920.—According to this invention, the upwardly-projecting discharge tubes 4 of a cooling tower are each provided with a co-axially mounted stepped-cone 5 having its smaller end below and fixed at a sufficient distance from the upper or discharge end of the tube as to cause the liquid to



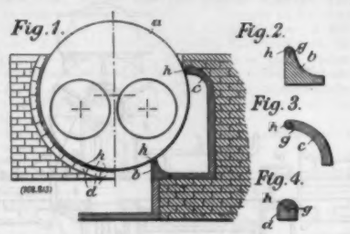
strike against the stepped-cones. The liquid on encountering the stepped-cones is split up into minute particles, which are delivered in the form of spray over the cooling stack. The lowermost cylinder of each of the stepped-cones is made of less diameter than the bore of its corresponding discharge tube. As a consequence, the liquid strikes against all the steps of the cones and a very efficient spraying of the liquid is ensured. (*Sealed.*)

169,824. Babcock and Wilcox, Limited, London, C. S. Davey, London, and A. Spyer, London. Mechanical Stokers. (1 *Fig.*) July 7, 1920.—In mechanical stokers in accordance with this invention, air under pressure is supplied beneath the grate through the transverse admission chambers and also air under natural draught is supplied simultaneously to the stoker at points between and outside of the transverse admission chambers. A plurality of pressure air distributing



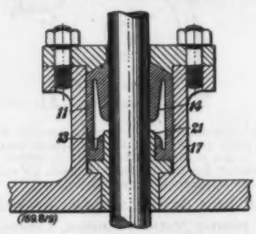
chambers A is provided. The pressure air is supplied from a main trunk through branches, all of which have openings into the chambers A. The air distributes itself to the underside of the fuel bed which is carried on the revolving chain B by means of openings on the upper side of the chambers A. The chambers A are, as shown, spaced apart, allowing the supply of air under natural draught simultaneously through the spaces A^7 between the air chambers A. (*Sealed.*)

168,813. C. E. Tetlow, Hollingwood, near Oldham. Boiler Settings. (8 *Figs.*) December 7, 1920.—The invention has particular reference to the bricks or tiles used in boiler settings as seating blocks, flue cover blocks, end blocks and the like for the purpose of supporting and partially enclosing the boiler. According to this invention, a brick or tile, for use in a boiler setting, has a contact surface of asbestos or the like formed by applying to the brick or tile a strip of such jointing material moulded and pressed to afford a rounded contact surface on one side and a relatively narrow rib or extension on the other side, the rib being secured in a correspondingly shaped groove in the brick or tile by pressure. *a* represents the boiler shell, *b* one of the seating blocks, *c* one of the flue cover blocks, and *d* the end blocks which engage the boiler shell at each end thereof. These blocks, in addition to supporting and positioning the shell, also serve to provide seals for the gas passages. Each of the various bricks or tiles mentioned is provided with suitable grooves or recesses, such as *g*, to receive a correspondingly-shaped rib or



projection on the back of a strip A of fire-resisting material, the opposite side or face of the strip being rounded as shown, in order to provide for the least possible area of contact with the shell. (*Accepted September 21, 1921.*)

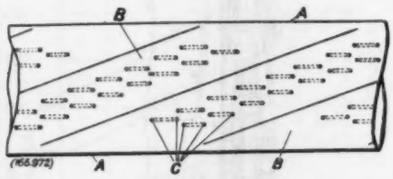
169,819 H. S. Hele-Shaw Westminster London, and E. Tribe Westminster, London. Piston Rod Packing. (1 *Fig.*) July 6, 1920.—The packing consists of a hollow ring 11 of non-metallic material arranged with its outer surface rigidly supported in a casing or housing 17. The packing is constructed with an opening on its inner side of such a depth as to leave



inturned lips or edges 13, 14 on the inner side adapted to be exposed to fluid pressure. According to the invention, the inner edges or lips 13 fit on a fixed sleeve or bush 21 on the cylinder end or valve casing co-axial with the rod or spindle, while the edges or lips 14 embrace the rod or valve spindle. (*Sealed.*)

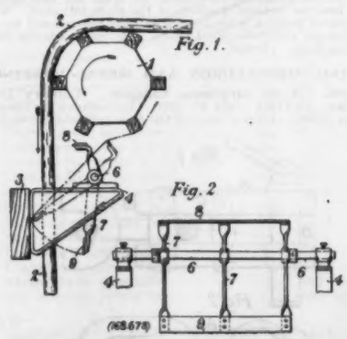
TEXTILE MACHINERY.

166,972. D. S. Meilish, Wortley, Leeds, and J. Ramsden, Wortley, Leeds. Carding Machine Cylinders. (2 *Figs.*) April 24, 1920.—To dispense with hand fettling there is applied, according to this invention, to the various cylinders and rollers of a carding machine, a fettling roller A partially covered with card clothing or filleting B of the bent tooth type, applied in



spiral form. The teeth C are set coarsely with their root portions parallel to the axis of the roller, which is run continuously in contact with the cards at differing speeds and is rotated in either direction, with or without traversing, as may be necessary according to the specific cylinder or roller to which it is applied. (*Sealed.*)

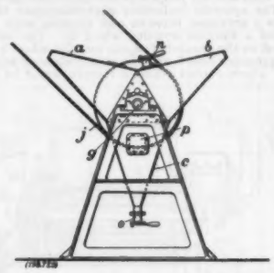
168,678. The Bleachers Association, Limited, Manchester, J. Morris, Adlington, C. Morris, Adlington, and G. W. Morris, Adlington. Treating Fabrics. (2 *Figs.*) June 8, 1920.—The invention relates to machinery employed in treating fabrics which in the course of such treatment are passed over a wince. The object of the invention is to sever automatically the fabric under treatment, which usually travels at a somewhat rapid rate, if it should adhere to and become



wound upon the winces to the consequent danger of injury to the person handling the fabric. The fabric 2 under treatment passes over the wince 1 in the direction indicated by the arrow (Fig. 1) on its way to the kier (not shown). On a beam 3 are fixed bearing carrying brackets 4 in which is mounted a fixed shaft 6. Mounted unequally upon the shaft 6 and loose thereon are levers 7. The extremities of the short arms of the levers 7 are cranked and carry a bar 8 which is formed with a sharp edge as shown in Fig. 1. The long arms of the levers 7 are of such length that in the position indicated by the dot and dash lines in Fig. 1 they will engage or come into contact with the beam 3. The long arms carry a bar 9 having a serrated edge, as shown in Fig. 2. In the normal position of the parts, the levers 7 take up an approximately vertical position, as indicated by the full lines in Fig. 1, so that the bars 8 and 9 are kept out of the path of the fabric 2 passing over the wince so long as it does not deviate from its path of travel. If, however, the fabric 2 adheres to or becomes wound upon the wince 1, as indicated by the dotted lines in Fig. 1, it will be carried in the direction of the bar 8 by which it will be caught. The levers 7 are rocked, and the bar 9 pins the fabric 2 against the beam 3, as shown by the dotted lines in Fig. 1. The fabric is severed by the sharp edge of the bar 8 or by the bar 9, thus averting any danger to the person handling the same before the machine can be stopped. (*Sealed.*)

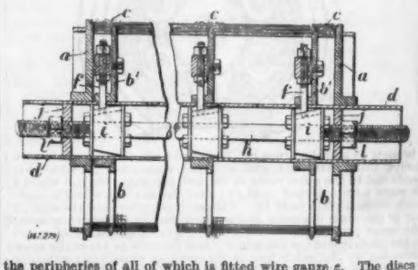
MISCELLANEOUS.

168,729. A. B. Smith, Fairfield, A. A. Skelley, Marple, and Continuous Reaction Company, Limited, Battersea, London. Mixing Granular Substances. (2 *Figs.*) July 2, 1920.—A rotary mixer, preferably for dry materials, is constructed of a number of radially-disposed chambers *a*, *b*, *c* of pyramidal form, gradually increasing in cross-section towards the axis of the mixer, the chambers being closed at the narrow end and open at the base and so arranged that their bases are secured over openings in the sides of a prism on the axis of which the mixer rotates. The chambers, which are preferably of



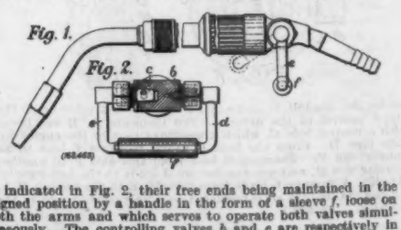
rectangular cross-section, are of depth greater than their width or length at the base, and also of depth greater than the diameter of the prism. The mixer is constructed with an odd number of chambers arranged at equal angles round the mixer so that the centre of each is diametrically opposite the angular junction of the two opposite chambers. The mixer is provided with filling, emptying and inspection openings *n*, *o*, *p*, respectively, having dust-proof covers, and is mounted on a shaft *g* carried in bearings in standards and driven by a pulley *j*. (*Sealed.*)

167,279. T. J. Marshall and Co., Limited, Stoke Newington, London, and R. E. Wedgwood, Stoke Newington, London. Paper-Making Machines. (3 *Figs.*) May 4, 1920.—In expanding cylinder moulds and dandy rolls employed in paper-making machines, which are made in separate segments movable radially relatively to the axis of the cylinder or roll, the radial movements of the segments are, according to this invention, positively effected in both directions. The mould roll comprises a pair of end discs *a* and a series of intermediate discs *b* around



the peripheries of all of which is fitted wire gauze *c*. The discs are fixed upon the hollow shaft *d*. The movable segments comprise separate portions b^1 of the discs *b* and gauze *c*. *f* are radially-disposed rods carrying the movable segments b^1. The inner ends of the rods extend through holes in the shaft *d* and engage cams *i* on a camshaft *h* within the shaft *d*. The camshaft *h* is adjustable longitudinally of the shaft *d* by the rotation of nuts *b* thereon and bearing against discs *j*. (*Sealed.*)

168,466. C. Hoddle, Westminster, London, and Thorn and Hoddle Acetylene Company, Limited, Westminster, London. Oxy-Acetylene Blow-pipe Burners. (8 *Figs.*) June 25, 1920.—According to this invention, the oxygen and acetylene controlling valves of an oxy-acetylene blow-pipe burner are arranged with their operating levers connected together by a common controlling handle. *b*, *c* are the taps or valves for respectively controlling the supply of oxygen and acetylene to the burner tube. *d*, *e* are the respective actuating arms of the plugs or taps *b*, *c*, the arms being cranked so as to be in alignment,



as indicated in Fig. 2, their free ends being maintained in the aligned position by a handle in the form of a sleeve *f*, loose on both the arms and which serves to operate both valves simultaneously. The controlling valves *b* and *c* are respectively in the form of a screwdown valve and a plug tap or valve in axial alignment and it will be seen that when the arms *d* and *e* connected thereto are moved by the sleeve *f*, both valves will be opened, the oxygen valve *b* opening slightly before the acetylene valve *c*, which latter will therefore close before the oxygen valve. (*Sealed.*)